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Illinois Technograph

James Chisholm, class of '41,
speaks from experience when he says,

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James Chisholm is typical of the young men who rapidly rise to an important position at U.S. Steel. Jim came to U.S. Steel as a trainee in 1941 after graduating as an M.E. Shortly thereafter he entered military service for four years. Upon his return to U.S. Steel in 1946, he advanced steadily until, in 1951, he was appointed to his present position as Assistant Superintendent of Blast Furnaces at the new Fairless Works at Morrisville, Pa.

Jim is now in charge of the unloading of all ore ships and the operation of the plant's two big blast furnaces—each with a rated output of 1500 tons per day.

Jim feels that the opportunities for graduate engineers are exceptional at U.S. Steel. He remarked that in his own department alone, six college trainees have been put into management positions within the last couple of years. He says that chances for advancement are even better now with the current expansion of facilities and the development of new products and markets.

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THE ILLINOIS TECHNOGRAPH

volume 70 **number 8**

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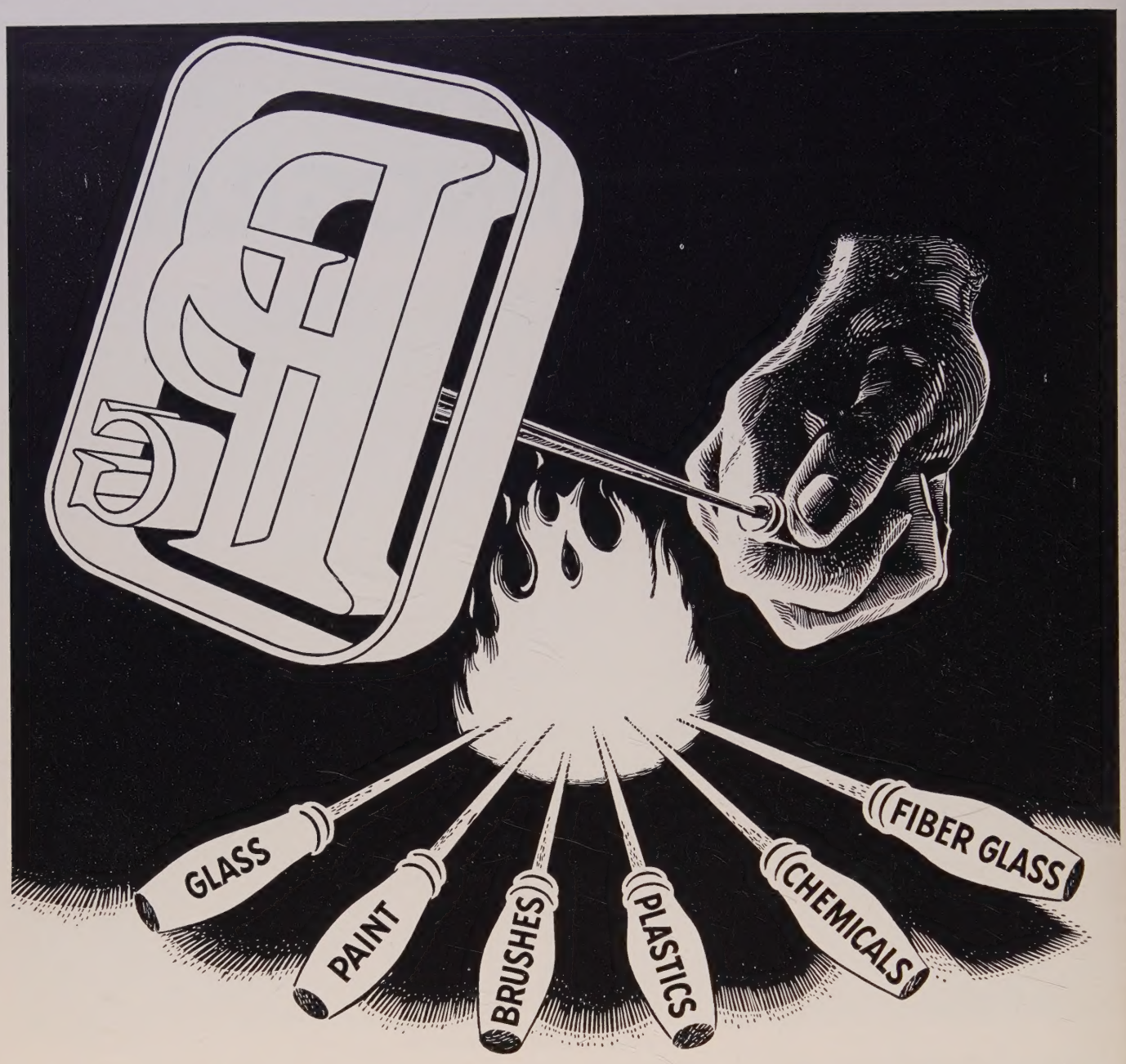
our cover

Civil Engineering Hall is the original engineering building on the Illinois campus. Today it not only houses the Civil Engineering Department, but also the offices of the College of Engineering.

our frontispiece

Radar is one of the most useful things on a battleship. The cannon can do very little without radar, and the radar needs the trusty gun to do its damage.



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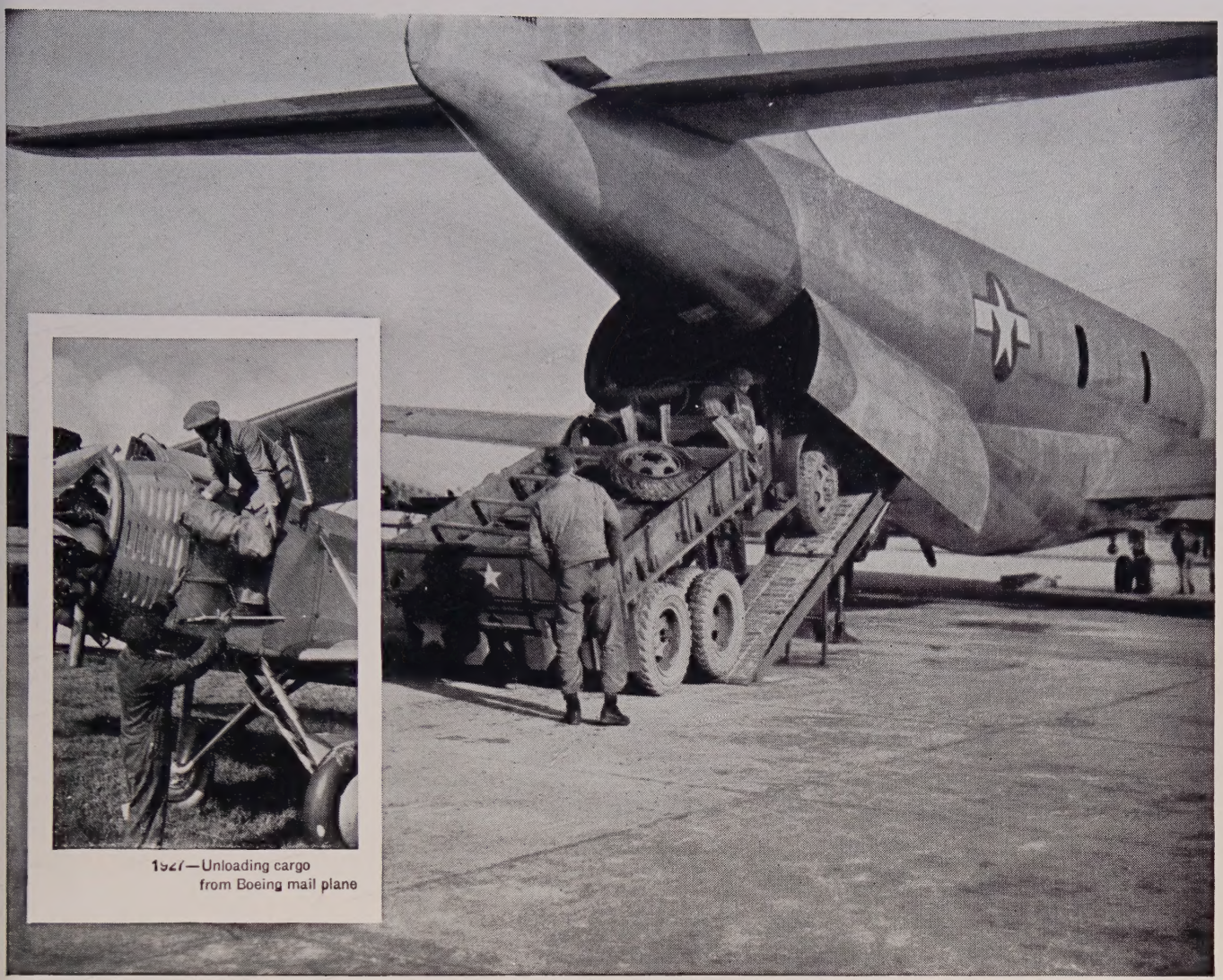


1927—Unloading cargo from Boeing mail plane

1955—Loading Boeing C-97 Stratofreighter

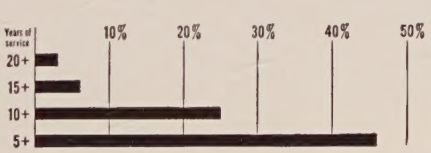
There's plenty of variety in Boeing engineering careers

America's pioneer passenger-cargo aircraft, the 40A, was a Boeing. So is the Air Force's versatile tanker-transport, the C-97 Stratofreighter shown above.

During the company's 38-year history, Boeing engineers have blazed new trails in the design of aerial freighters and tankers, commercial airliners, flying boats, fighters, trainers and bombers. Today Boeing continues to offer engineers a wide variety of opportunities in Research, Design and Production.

Students sometimes are surprised that Boeing's engineering staff includes those with civil, electrical, mechanical, aeronautical and other engineering degrees. Yet all find application in aviation. For example, the civil engineer may work on airframe structure or stress. Electrical engineers find challenge in the complicated electrical and electronic systems of modern jet bombers and guided missiles. Other engineers will find similar application for their talents.

The high degree of stability in careers at Boeing is reflected in this chart.



It shows that 46% of Boeing engineers have been with the company five or more years; 25% for 10 or more years, and 6% for 15 years.

Boeing promotes from within, holds regular merit reviews to assure individual recognition. Engineers are encouraged to take graduate studies while working and are reimbursed for all tuition expense.

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THERE'S A SILICONE IN YOUR FUTURE

by Donnie Snedeker, E. E. 58

"If a silicone were a woman, you'd forget all about your first love and your pet cover girl. You'd set off in quest of the silicones, because they have all of the virtues you dream about but never find in one woman."[1]

Back in 1942, the coast of Europe was well known and the coast of China had been explored. Columbus assumed, therefore, that if he sailed west from Europe he would land on the coast of China. No one then knew that a great continent lay between Europe and Asia.

A similar condition had existed in the chemical world until the turn of this century. For years men had known about inorganic materials such as ceramics, glass, and metals. The field of organic chemistry had also been explored and chemists had developed plastics, rayon, and thousands of synthetic organic materials in the more recent past. No one knew that "between these two fields lay a new chemical continent of semi-inorganic materials known today as silicones." [2]

Silicones are synthetic compounds composed of silicon and orygen from the inorganic field and hydrocarbons from the organic fields. These substances are never found combined in nature and they don't join readily by chemical means. For this reason their combination is often thought of as a chemical "shot-gun wedding." [3]

Once this marriage has been completed and the silicones are formed, it takes considerable energy to break them down. This results in remarkable properties which accounts for the wide variety of uses for silicone compounds.

Before a substance can have this potentially infinite number of uses it must first be discovered and developed. Early experimentation was probably hindered by the lack of natural products to study. From the very beginning synthetic methods had to be developed. This task was undertaken by some of the ablest scientists of the nineteenth century—Crafts, Landenburg, and Friedel. Their studies enlarged the knowledge of silicon, the element, and laid the ground work for preparation of silicones. The methods they used were rather laborious and the results were not particularly remarkable. Consequently, s i l i c o n e s were were pretty much forgotten until the turn of this century when an English professor began his 43 years of monumental research into the field.[4]

In 1901 Professor Frederic S. Kipping of the University of Nottingham in England published the first of 54 papers on the subject of silicone research.[5] The professor, who died in 1949 at the age of eighty-five, has been described as a "distinguished, meticulous, revered scholar and teacher, and a good man with billiard cue, tennis racket, and cricket bat"[5] who "devoted more than four decades to the basic investigations which now support modern silicone science." [6]

Kipping was not interested in the uses for silicones, but he primarily directed his work toward preparation and characterization of new compounds, and a study of their reactions. He and his students isolated these compounds in an effort to obtain pure compounds. Their equipment often became clogged with "uninviting" glues and oils. Some of their products were gases, many were liquids and solids, and several were labeled as "glass-like messes." These products were found to be composed of long chemical chains of alternate silicone and oxygen atoms with various hydrocarbon groups attached to the silicon atoms like branches on a tree.[8]

The Grignard reaction,[9] a most effective means of attaching organic groups to silicon, was discovered by Kipping in 1904, which made it simpler for others who were beginning to work in this field. Alfred Stock of Breslau began studying compounds in which hydrogen atoms were attached to silicon. He found that the longer chains are less and less stable. This study opened the door for Bygden's work on the analogous physical properties of certain carbon compounds and similar silicon compounds.[10] Many scientists dabbled in silicon research but up until industry's plunge into the field the major advances were made by Professor Kipping and his students.

Russia tried to get in on the show in 1930 when their scientists released a number of papers on the subject. They were the first to sense the industrial value of various types of silicon compounds, but they failed to follow up. Dr. Kreshov of the Mendelsef Institute in Moscow stated that the reason Russia did not pursue such an encourgaging start could be attributed in part to the lack of magnesium to operate the Grignard method. Recently they have published reviews of previous work and reports of developments in America which might indicate a renewed interest in the subject.[11]

About the time Kipping and his associates were cleaning the "glass-like messes" from their test tubes, American scientists were turning these basic discoveries into a new chemical industry. Glass manufacturers were looking for a resin which would match the properties of glass fibers. Officials at Corning Glass Works of Corning, New York, saw the possibility of such a resin in Kipping's silicones. They engaged Dr. J. F. Hyde, an organic chemist to head their research.[12] In 1935 Corning introduced Fiberglas cloth, woven of glass fibers. Fiberglas looked promising as an electrical insulation material if some non-conducting, heat-stable impregnant could be found for a good bond. Studies and experimental work began along these lines by Dr. Hyde. He made hundreds of silicone resins that were either too stiff or too sticky before he finally came across one that seemed to have the ideal

combination of the needed properties. Then Corning began contacting electrical companies about their new discovery and they extended their research activities to a fellowship at the Mellon Institute in Pittsburgh under the direction of Dr. Rob Roy McGregor.[13]

With their experimental research going full speed, Corning officials decided to join forces with a large chemical manufacturer in order to go into full scale production. They contacted Dow Chemical Company because Dow was the largest supplier of magnesium, which was a major ingredient in the Grignard method of producing silicones. The officials at Dow agreed and in 1943 the Dow Corning Corporation was formed with headquarters at Midland, Michigan.[14] The new corporation's first product was a "smooth, colorless compound that looked and felt like white petroleum jelly, remained jelly-like at any temperature from 40° below Zero to 400° above, and blocked both water and electrical currents."[15] This jelly, called DC (for Dow Corning) 4, was used as an ignition-sealing jelly for sparkplug terminals on fighter planes. This product played an important part in preventing ignition failure during World War II.

While this first product was making history, Dow Corning officials were selling the Navy Department on insulating submarine motors with silicone-resin impregnated Fiberglas. After a tour of the Dow Corning pilot plant, Admiral Rickover—then head of the electrical section in the Bureau of Ships—was thoroughly impressed and convinced, and he contracted them to begin construction of silicone-insulated motors. This contract made it possible for Dow Corning to construct a $3,000,000 plant which they had operating by 1944. They were testing experimental silicone-insulated motors when the war ended and the silicone market collapsed temporarily.[16]

Although Corning was the first company to consider silicones seriously, General Electric was not far behind. In the middle 30's they began research under the guidance of Dr. Eugene Rochow and Dr. Winton Petnode. Dr. Rochow developed the "direct method" of producing silicones which has become the key to modern volume production. It replaces the slow and complex Grignard method that was used by Professor Kipping and his students.[17]

By 1938 General Electric had succeeded in developing a silicone insulation that was remarkably resistant to heat, water, and most chemicals. One of the G.E. scientists, Dr. J. G. Wright, in the midst of his experiments, discovered the black sheep of the silicone family—bouncing putty. This turned out to be of little practical value, and it may be remembered as a Christmas novelty of a few years back. It stretched like elastic, drooled like tar, bounced like a ball, or cracked like peanut brittle.[18]

With laboratory competition in full swing many discoveries were made accidentally. One day Dr. Maynard Agens of G.E. noticed that a silicone liquid had reacted with a metal stopper to form a rubber substance. He developed a simple production process and, because of the silicone rubber's astounding heat stability, G.E. began using it to replace the rubber gaskets in their turbochargers during World War II. By the end of the war General Electric had advanced far into the field of silicone research.[19]

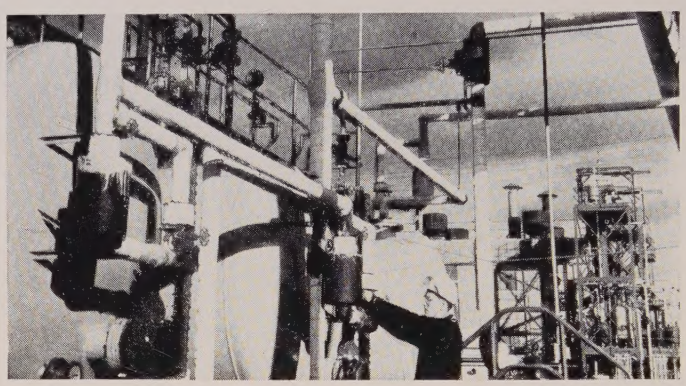
Dr. W. R. Collins, vice president of Dow Corning, once said, "Our salesmen have one big problem. When they are looking for new business, they don't know where to stop. Any plant they go by—no matter what they make—could find a use for silicones."[20] Apparently other companies saw this great diversification in the store for silicones, also. In 1949 the Plaskon Division of the Libbey-Owens-Ford Glass Company began selling silicone products. Their attention is being mainly directed toward paints which combine silicones and alkyd coatings to obtain covering characteristics between porcelain and paint. Plaskon ranks as fourth in present day silicone production.[21]

Ranking third in production of silicones is a newcomer—Linde Air Products Company, a subsidiary of Union Carbide and Carbon Corporation. They recently completed construction of a $13,000,000 plant at Long Reach, West Virginia. Unlike the other silicone producers Linde has its own supply of silicon. It comes from a fellow subsidiary, Electro Metallurgical Company.[22]

As has been previously mentioned, silicones are a combination of sand, oxygen, and hydrocarbons. They combine the best properties of these groups to produce astounding results. The silicon and oxygen partners give the silicones their stability, i.e., their ability to resist heat, cold, chemicals, and weather. The hydrocarbon partner makes silicones flexible. By varying proportions and types of this partner, the chemist can produce silicones ranging from volatile liquids to stable solids. "Millions of silicone combinations are theoretically possible," according to Dr. Charles E. Reed, general manager of G.E.'s Silicone Products Department.[23]

More important than the appearance are the four basic properties of silicones, none of which has yet attained maximum use. First, silicones offer outstanding resistance to extremes of heat or cold. They remain stable, retaining their properties, up to about 550° Farenheit or as low as 120° below Zero.[24] The heat stability of silicones is an inherent feature in their chemical structure. It makes them a very suitable electrical insulation material in complement with fibrous glass, mica, and asbestos insulating materials. Silicones can serve as a bonding agent to hold these materials together and also to bond them to the metal. An application of this property of silicones is its use in heater ducts for jet aircrafts, which are subjected to opposite extremes between the hot-air blasting through them and the freezing temperatures outside.[25]

A second inherent feature in silicones is their amazing release characteristics. Certain silicone compounds apparently fail to react with most other substances. This makes it possible for them to be used in such strange places as the deicer boots on aircraft wings. Many manufacturers of molded articles are taking advantage of this property of silicones by using them as release agents. A thin film is spread over the metal die and the hot rubber or plastic article will not stick.[26]



One of General Electric's plants which has all of the outside pipes and tanks covered with multicolored silicon coatings to protect them against the weather. A standing testimonial to its products.

This pretty model appears mystified by the strange bouncing putty. A Christmas novelty of a few years ago, bouncing putty bounces like a ball, drools like tar, or shatters like glass when struck hard.

The U. S. Army has plans to make use of silicon's ability to repel water. This silicon coated compass will always function properly without any danger of water entering the case.

Water-repellency is another surface property of major importance for silicones. When a surface is coated with silicones, the silicon-oxygen partners attach to the surface, leaving the hydrocarbon partner exposed. This acts like a paraffinic umbrella for the rest of the molecule. Multiplied by each of the molecules this forms a waterproof raincoat for the surface. Although silicones keep the water out, they allow air to come in because the silicones coat the pores without clogging them.[27]

In many instances the chemical inertness of silicones can be a manufacturer's asset. Often this versatile substance can be extremely lazy, and therefore useful. Silicones refuse to react with most materials, which enables them to resist decomposition and weathering. An example is silicone fluid coatings on porcelain that shed dirt, won't crack under hot sunlight and resist formation of continuous films of water. Silicone rubber is insoluble in most organic solvents. This allows silicone rubber to be used as a selant on small transformers that will not contaminate the liquid electrolyte.[28]

These vital characteristics of versatile silicones are being put to work in many commercial products for both consumer and industry. The first such product was an eyeglass cleaning tissue called "Sight-Savers." Made by Dow Corning, these pink-colored tissues drew nationwide attention to silicone products. Today they may be found in 80 per cent of the nation's drug stores. Many

Here a scientist tests silicon rubber's astounding resistance to cold temperature. Even after being extremely cool by dry ice, the silicon rubber retains its flexibility with no noticeable effects.

concerns are now giving them away like matchbooks for advertising purposes. Silicones have a natural affinity for glass—they are partly composed of silicon dioxide (sand) which is an important ingredient in glass—which makes them well suited for glass cleaning tissues.[29]

Since silicone's debut there have been many worthwhile silicone-containing products flooding the market. Top architects are recommending silicone-based, water-repellent treatments for masonry ways. This treatment, dubbed "Stop-all," provides up to ten years protection for cinder block, concrete, plaster, brick, stone, or stucco. It also prevents the formation of the white powder that often disfigures brick, and it prevents muddy water from seeping into the pores, thereby giving the bricks a cleaner appearance.[30] Thomas Jefferson's home and the Field Museum in Chicago are shining testimonials to the coating powers of silicones.[31]

However, this coating protection is not confined to masonry alone. Many paints on the market today have a silicone base. They were basically developed for use on arctic shelters (where they keep off the snow and ice), space heaters, and exhaust manifolds (where they retain their good looks at high temperatures), but they are being used successfully in homes and industries. The silicone additive also increases the ease with which the paint flows. It gives a satin-smooth finish without any betraying brush-marks.[32] After the basement and sides of the house have been protected with silicones, the job can be completed with silicone-coated asbestos shingles that are now being offered by several manufacturers.[33]

The use of silicone as a polish for cars and furniture has gained a well merited popularity. "Autobrite," one of many brands on the market for automobiles, advertises easier application, longer life, and water-repellency.[34] The time required for polishing a car with a silicone fluid is variously estimated at one-half to one-fourth that required with a good hard wax. It lasts for six months on one application, has a luster equal to that of a hard wax, and bettter resists water and dirt because, unlike wax, there is no softening with heat. The hard glass-like finish even retards water and fingermarks.[35]

Likewise, furniture polish has the same advantages with silicone additives. It gives improved luster, reduces water spotting, and makes a hard wax easier to rub down. The grain of the wood is brought out more distinctly and a curious "releasing" quality prevents dust from sticking to the surface. Once the coating has been applied, a silicone-impregnated dust cloth polishes the furniture as it is dusted. This polish can even be used to minimize rings in a bathtub, or to apply a protective finish to phonograph records.[36]

The first industry to realize the advantages of silicones as release agents was the bread-bakers. "Pen-Glaze" is a silicone coating which bakers use to eliminate greasing and degreasing the pans. Harvard Baking Company of Midland, Michigan, was the testing grounds. They found that it gave easy release of bread for 150 to 200 bakings. Word spread from baker to baker, and now most bakers are taking advantage of it.[37]

Another major use for abhesives, the opposite of adhesives, was opened when a Dow Corning chemist visited one of his friends at the United States Rubber Company plant in Detroit. The rubber company decided to apply a silicone treatment to its tire molds and soon reported that its daily production of scrap tires—tires that stick to the mold and become deformed—had dropped from 1,000 to essentially none.[38]

Dow Corning's "Sylmer" and General Electric's "DeCatex 1107" are being used to effectively water-proof silk, viscose, acetate, cotton, nylon, and even wool and the glass fibers. The silicones are impregnated into the material to invisibly coat each fiber with an impermeable film. They make the material feel softer, smoother, or more resilient, depending upon individual choice, by adding various types and amounts. Any normal staining liquid may be brushed off or blotted up before it soaks in, and practically any spot can be cleaned away with water. Silicones even increase the sewability of the cloth because they lubricate the needle.[39]

These are but a few of the infinite number of uses for silicones. Daily, new uses are being discovered by the scientist and by homeowners. Mrs. Richard L. Talbot found that if silicone lotion was applied to her hands before washing the dishes, she could escape red, irritated, "dishpan hands." It even cleared up her baby's diaper rash. The University of Wisconsin Medical School, upon Mrs. Talbot's suggestion, investigated this use and found that it cleared up 58 of 61 cases of skin irritation that had failed to respond to other therapy. Now the Talbots are in business marketing their discovery.[40]

Future uses for silicones include greaseless frying and cooking. A thin coat of silicone will be applied to pots and pans to eliminate the need for messy grease. The coating will be on the utensils when they are purchased, and after many hours of use a new coat may be easily brushed on at home. Similar coatings will keep ice from clinging to trays, prevent irons from sticking to fabrics, and allow food containers to be drained to the very last drop.[41] One authority looked into his crystal ball and prophesied that "the automobile of 1975 will use silicone rubber for heat-resistant gaskets, wire insulation, and engine block cushions. Silicone oils will be used as brake fluid, as the damping for hydraulic springs, as the lubricant for speedometers and other instruments. Upholstery will be water-proof and stain-proof. Silicone automobile finishes will likely last for the life of the car with no need for waxing and polishing." [42]

Yes, there is a silicone in your future!

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[1]"Miracles from Sand," *Newsweek,* XLI (June 1, 1953), 60.
[2]S. L. Bass, "Silicones—A New Continent in the World of Chemistry," *Electrical Engineering,* LXVI (April, 1947), 32.
[3]*Ibid.*
[4]Eugene Rochow, *An Introduction to the Chemistry of the Silicones* (New York: J. Wiley and Sons, 1951), 1.
[5]Complete listing of all of Professor Kipping's papers on silicone research may be found in An *Introduction,* p. 60.
[6]Milton Silverman, "Scientist's Goofiest Discovery," Saturday Evening Post, CCXXVII (February 26, 1955), 36.
[8]*Ibid.,* p. 37.
[9]The Grignard reaction and other chemical processes which may be mentioned later are described fully in *An Introduction.*
[10]Rob Roy McGregor, *Silicones and Their Uses* (New York: McGraw-Hill, 1954), p. 17.
[11]*Ibid.,* pp. 18.
[12]"Newest Synthetic Family," *Business Week,* (March 29, 1947), p. 49.
[13]Silverman, p. 126.
[14]Silverman, p. 126.
[15]*Ibid.*
[16]*Ibid.,* p. 127.
[17]General Electric College Press Section, *Forecasts Indicate Greater Use of Silicones* (New York, 1954), p. 6.
[18]Silverman, p. 35.
[19]*Ibid.,* p. 127.
[20]"Miracles From Sand," p. 60.
[21]"Plaskon Eyes Silicones," *Business Week* (September 5, 1953), 70.
[22]"Another Boost for Silicones," *Business Week* (February 3, 1951), 68.
[23]*Forecasts Indicate,* p. 3.
[24]*Ibid.,* p. 4.
[25]"Silicones—A New Continent," p. 32.
[26]*Forecasts Indicate,* p. 4.
[27]"Silicones—A New Continent," p. 32.
[28]*Forecasts Indicate,* p. 6.
[29]"Getting Silicones Started," *Business Week* (April 30, 1949), 84.
[30]M. Gough, "You Should Know About Silicones," *House Beautiful,* XCVII (January, 1955), 66-67.
[31]"Silicones: A New Touch for Daily Life," *Business Week* (January 9, 1953), 134.
[32]*Ibid.*
[34]"Silicones for Waterproofing and Auto-Polishing," *Science Digest,* XXVIII (August, 1950), 94.
[35]McGregor, p. 63.
[36]Gough, p. 70.
[37]"Getting Silicones Started," p. 84.
[38]Silverman, p. 127.
[39]"Silicones Give Wool Fine New Repertory," *Business Week* (April 24, 1954), 32.
[40]"Silicones, Magic Sand with a Thousand Uses," *Reader's Digest,* LXII (February, 1953), 29.
[41]J. Polshek, "What You Should Know About Silicones," *House Beautiful,* XCV (September, 1953), 201.
[42]"Silicones: A New Touch."

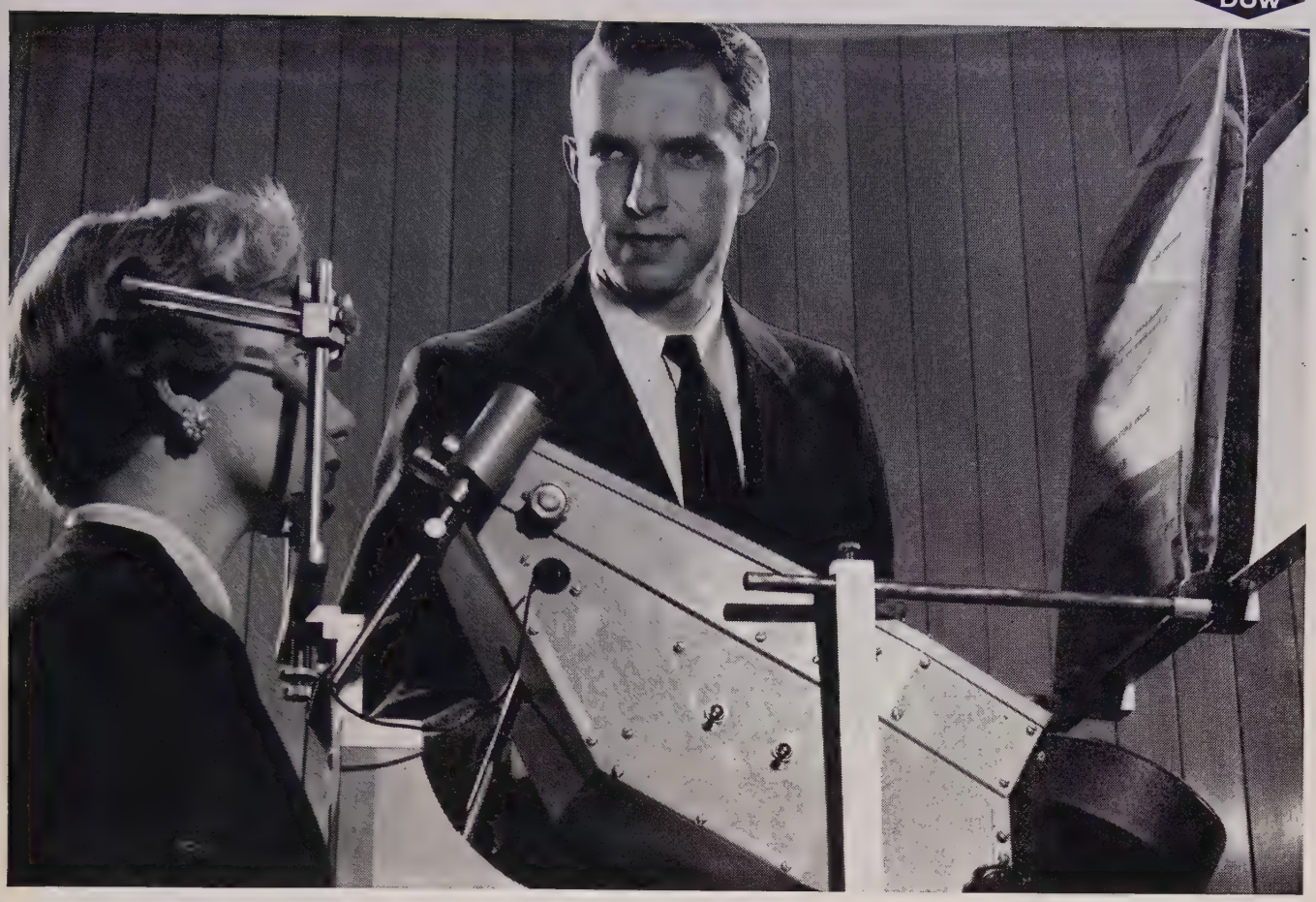
An Arab furtively stepped on a scale
Near the end of a lingering day
A counterfeit coin he dropped in the slot
And silently stole a weigh.

* * *

Then there was the out-of-town student who got thrown out of his apartment when the landlady heard him drop his shoes on the floor twice.

* * *

He: "Whisper those three little words that will make me walk on air."
She: "Go hang yourself."



MUCH MORE THAN MEETS THE EYE GOES INTO DOW PACKAGE DESIGN

Engineers and ocular cameras, salesmen, lawyers and artists combine talents to produce a unified "sales team" for Dow

Tin cans and tank cars, cardboard cartons and fiber drums, bags and bottles of sundry shapes, carry Dow products to world markets. In addition to quickly describing its contents, each package should speak for the product's quality and should reflect the company which produced it. Dow recently redesigned its packages with these objectives in mind.

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by John Graves, M. E. '58

Waves of a certain length affect the optic nerve of our eye and are called light waves. Just as our ears are sensitive to air waves of certain lengths, so our eyes are sensitive to ether waves of certain lengths. The theory of ether waves was brought about by the facts known of radiation.

We receive heat from the sun by radiation. Since heat is a form of energy produced by the motion of the molecules, waves are set up in the surrounding medium. A scientist, Huygens, advanced the wave theory to account for the transmission of radiant energy. Radiations travel through a vacuum; so he presupposed the existence of a very subtle medium which pervades all space and transmits radiant energy. This medium is called ether. It is supposed to be an invisible fluid, so very rare that it cannot be weighed or measured; it easily penetrates intermolecular spaces.

As early as 1678, Huygens proposed his wave theory of light and suggested that light waves are ether waves. However, the theory was opposed to such an extent that it was delayed one hundred years. His theory was opposed by Sir Isaac Newton's corpuscular theory. According to the corpuscular theory, or the emission theory, streams of extremely small particles of corpuscles are emitted by luminous bodies. Such corpuscles produce the sensation of light when they enter the eye and stimulate the optic nerve.

When Huygens assumed the existence of the ether as a medium through which light waves are transmitted, men of the eighteenth century found it difficult to accept such a theory. It is difficult to try to picture a medium which we cannot see, feel, smell, or taste. We find it hard to imagine a weightless fluid so subtle that it slides in between the molecules and pervades all space, even that of a vacuum. However, the theory has been accepted because it is difficult to explain some of the phenomena of light by the corpuscular theory.

In 1864, James Clerk-Maxwell, one of the greatest of modern physicists, suggested that light has its origin in ether waves set up by electrical disturbances. His elestromagnetic theory of light has been commonly accepted, especially since the experiments of Heinrich Hertz seem to confirm Maxwll's suggestion. It is possible then, that light waves are ether waves which have their origin in the vibrations of electrically charged particles which compose the atoms themselves.

Still more recently the quantum theory of light has been proposed. Max Planck of Berlin suggested in 1900 that light is transmitted in small bundles or packets of energy called photons, or quanta of light. Einstein's experiments confirm this theory, and his theory of relativity has made many scientists skeptical of the existence of the ether. To explain all the various phenomena of light it seems to be necessary to use the quantum theory and the wave theory.

Light waves differ in several ways from sound waves: (1) Light waves travel through a vacuum, while sound waves do not. Hence, light waves are ether waves, but sound waves must be transmitted by ordinary matter. (2) Light waves are transverce, while sound waves are longitudinal. (3) Sound waves vary in length from 1 cm. to nearly 21 meters, while light waves range from 0.000039 cm. to only 0.000081 cm. in length. (4) Light waves travel in straight lines, but sound waves bend around corners readily. We can hear a person who stands around the corner from us, but we cannot see him. (5) Light travels so rapidly it is considered instantaneous for short distances. The speed of sound is very slow compared to that of light. In one second light travels a distance equal to more than seven times around the earth at the equator.

There are two sources of light, natural and artificial. Nearly all the natural light that we receive comes from the sun. However, the distant stars furnish us with some light. Some of the stars are larger than our sun and give off more light, but they are so far away that we receive only a tiny fraction of the light that they emit. The moon-light is caused by the reflection of the sunlight off the moon. It has been established that the giant star Betelgeuse has a diameter of about 235,000,000 miles, but the sun is only 866,000 miles in diameter.

There are several ways of producing artificial light, Friction may be used to heat objects until they glow. When gas, oil, or other fuel burns light is produced. Electricity is used to heat tungsten wire to incandescence, or until they glow. Sometimes burning fuel is used to head objects to incandescence.

Now we reach the problem of distinguishing between luminous and illuminated objects. If a platinum wire was to be heated, the ether waves that are set up become shorter and shorter as the temperature rises. The wire soon begins to glow, or it becomes incandescent. It is a luminous body, visible on account of its own light. An object that gives off light on account of the energy of its own oscillatory particles is said to be luminous. The stars are luminous and emit light.

Just as sound and heat are reflected, so light waves may be turned back from the surface of bodies. Mirrors reflect light that is received from some other source. A body that merely reflects light which it has received is an illuminated body. The moon is an excellent example. Like a huge mirror, it reflects light which it receives from the sun. Some of the planets may be hot enough to be luminous, but most of them are illuminated bodies, reflecting light received from other sources.

What happens when light waves fall upon the glass of our windows or upon the surface of the water? Part of the light is absorbed by the medium itself. The three charactreistics of light waves, reflection, absorption, and transmission can be explained as follows.

Smooth bodies of water have been used as a reflector of light from the earliest times. The panes of glass from the window of a distant house reflect light to us. However, if the glass is re-

Cliff Litherland asks:

Would I have varied assignments at Du Pont—or would I specialize technically?

CLIFFORD LITHERLAND received a B.A. degree from Rice Institute last year, and is now working for a B.S. in Chemical Engineering. He is Business Manager of "*The Rice Engineer*," and Vice-President of the fifth-year class at Rice. By asking questions of prospective employers, Cliff is trying to get information that will help him make the best use of his training in the years ahead.

ARTHUR I. MENDOLIA was graduated from Case Institute in June 1941 and started work with the Du Pont Company that same month. In addition to handling challenging assignments at work, he also enjoys some interesting hobbies. Although he makes no claims personally, he's classed as a minor authority on golf and hi-fi music. Mr. Mendolia is Assistant Director of Research for Du Pont's *Electrochemicals Dept.*

Arthur Mendolia answers:

Well, Cliff, I'd say the answer to that question depends largely on your own preferences. In a company the size of Du Pont there are opportunities for growth along either line.

In my own case, I've followed the route of diversification—and I think you'll find that's the general procedure when a fellow is interested in administrative work.

For example, after graduation I started work in the research lab at Du Pont's Niagara Falls plant. That was followed by two years of process improvement work, and a stretch as assistant supervisor over one of the plant areas. Next, I spent a few years in liaison on the design and construction of our first full-scale plant for making nylon intermediates from furfural. Then, I had assignments on "plant start up," and production supervision before I was given my present post. I was made Assistant Director of Research for Du Pont's *Electrochemicals Department* last August.

You see, variety of assignments means contact with new men and with constantly changing problems. That keeps interest alive. It leads to growth, too, because it provides a broad base of experience for future responsibilities.

On the other hand, some fellows prefer to become specialists in a particular field—and Du Pont has many opportunities for that type of professional growth, too. In our research, development and design groups we have experts on distillation, mass transfer, thermodynamics—and most anything else you'd care to mention in the field of engineering. These men are respected throughout the whole company for their technical knowledge.

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moved, we see what appears to be a dark opening. Also, highly polished metals make good reflectors of light. Dark colored objects are good absorbers of light. Black objects absorb all the light that is cast upon them. When the vertical rays of the sun strike a body of water, most of their light is either absorbed or transmitted. More of the rays are reflected when they strike the water at an oblique angle. Air, glass, and water transmit light readily. They are said to be transparent. Transparent bodies transmit so much light that it is easy to distinguish objects through them. Objects which transmit light but are unable to see through are translucent. Objects which do not transmit light at all are opaque.

Now the question is, how fast does light travel? Light travels so fast that it appears to be instantaneous. In fact, Galileo concluded that no time at all was required for light to travel from one place to another. His conclusion was accepted until a method of measuring light velocity was found.

The first experiment for measuring the velocity of light was performed by a Danish astronomer, Roemer. His experiment had to do with one of Jupiter's statelites and the position of the earth. First when the earth was on the side of the sun nearest to Jupiter and six months later when the earth was on the opposite side of the sun. In doing this he found that the eclipse occurred 16 min. 36 sec. later than the first time, and that he was 186,000,000 miles farther from Jupiter than before. So he calculated that if light travels 186,000,000 miles in 996 sec., then the velocity of light must be a little more than 186,000 miles per second.

There were other methods of finding the velocity of light, also. One of which was by using a mile-long vacuum tube. The vacuum tube was used to prevent errors due to haze and to varying density of air. A light was reflected back and forth ten times in this tube. The value obtained by this method is 186,285 miles per second, which is not believed to be more than one mile in error. The velocity of light in water is about three-fourths as great as in air. In ordinary glass it is about two-thirds as great. Light travels slightly faster in a vacuum than in air.

If a beam of sunlight was permitted to fall upon a glass prism through a narrow slit in a window shade, we could see a band of seven colors. Such a band of colors is called a solar spectrum. This shows that sunlight is complex and that it is composed of several colors; it is polychromatic light. If light consists of only one color, it is said to be monochromatic.

Such a method of analyzing complex light, or separating it into its colors is called dispersion of light. Such dispersion is due to the fact that some colors are refracted more than others as they pass through a glass prism. Violet light is refracted more than any other color, since it has the shortest wave length. Red rays are bent least in passing through a prism; they are the longest of the light waves. The other colors lie between the red and the violet. The other colors in order of refraction are, indigo, blue, green, yellow, and orange. The rainbow is a beautiful example of a solar spectrum cast across the sky by the dispersal of sunlight from drops of falling water.

Just as the pitch of sound depends upon the number of vibrations which reach the ear per second, so the color of light depends upon the number of vibrations which reach the eye per second. Color bears the same relation to light that pitch does to sound. When one end of an iron poker is held in a fire, the electrically charged particles in its atoms oscillate faster and faster as the temperature rises. Soon the vibration rate becomes fast enough to give off waves to which the eye is sensitive. The first color which the eye can detect is a very dark red. To produce this dark red color, the vibrations must be so rapid that the wave length produced is only 0.00081 mm. in length. Longer waves than this affect our temperature sense and are known as infra-red rays, but the eye is not sensitive to them.

It is difficult for pupils to think of color as a property of light waves rather than of objects. For example, we have a piece of cloth which we say is blue, but if we hold it in the red portion of a solar spectrum in a darkened room, we find that it seems black. If we put a piece of red cloth in the blue portion of such a spectrum, it will also appear black. What do we mean by saying that an object is blue? We mean that it absorbs all the light except blue, but it reflects the blue light to the eye.

From these observations, we must conclude that the color of an opaque object depends upon: (a) the color of the light that it can reflect; (b) the color of the light that shines upon it. Strictly speaking, color is a property of light waves that is dependent entirely upon their length.

Artificial lights are likely to be deficient in certain colors, particularly in the blue and the violet. The mercury vapor-lamp, which is widely used by photographers, is deficient in red and yellow rays. A person sitting under the rays of such a lamp loses his natural color.

The color of transparent objects depends upon the color of the light waves which they transmit. Ordinary window glass, which transmits all colors, is said to be colorless. Red glass absorbs all colors but red, which it transmits. The stars of the United States flag would appear red on a black field, if viewed through red glass.

If compound, or polpchromatic, light can be analyzed into its simple colors, it seems reasonable to suspect that one can combine simple colors to form compound light. This can be done in two ways. (1) If we place a second prism in the solar spectrum formed by a prism, the different colors will recombine to produce white light. Other colors may be compounded in the same manner. (2) If we have given a disc which has the spectral colors painted upon it, we may combine the colors by rotating the disc rapidly. Since we have duration of vision, the light from one color forms an image which persists on the retina until each of the other colors in turn has been reflected to the eye.

It is of interest to inquire how light waves of different length affect the eye in such a manner that we see different colors. The most generally accepted theory of color sensation was proposed by Dr. Thomas Young and later elaborated by Helmholtz. It is based upon the Young-Helmholtz color theory, the retina of the eye is provided with three sets of nerves, each set being sensitive to one of the three primary colors red, green or bluish-violet.

Now that we know that the sun's rays are separated into colors by a prism to form a solar spectrum, we should know the different kinds of spectra. Light from other sources may be analyzed in the same manner. There are three kinds of spectra:

(1) A platinum wire held in the colorless flame of a burner produces a spectrum that consists of an unbroken band of seven colors. Since the seven colors form one unbroken band, such a spectrum is said to be continuous. Continuous spectra are produced by incandescent solids, liquids, and dense gases.

(2) Another kind of spectra is the discontinuous spectra. If a platinum wire was dipped into a solution of common salt, or sodium chloride, and then held in the colorless flame of a burner surrounded by a piece of metal in which a narrow slit has been cut. When the light coming through this slit falls upon a prism, the spectrum which it forms on a screen consists of a bright yellow single line. Since this bright line breaks the continuity of the band of colors, such bright-line spectra are known as discontinuous spectra.

(3, We may produce bright-light spectra with luminous sodium vapor just as before, and then place an iron pan containing sodium chloride between the slit and the prism. When the pan is heated enough to vaporize the sodium chloride, but not hot enough to make it luminous, a dark line appears in the

spectrum where the yellow line had before. The yellow light waves have been absorbed by the sodium vapor. Such spectra are called dark-line, or absorptive spectra. Gases or vapors can absorb light waves of the same length they would produce themselves, if they were heated to luminosity. For example, luminous sodium vapor gives bright yellow light waves. Non-luminous sodium vapor absorbs yellow light waves.

When the sun shines upon drops of falling water a solar spectrum may be formed. Water disperses light in the same manner as a prism, but reflection and refraction of light are also important in forming the rainbow. As a beam of sunlight enters a drop of water it is refracted; dispersal also occurs. The red ray suffers total reflection the same as the violet ray. When they leave the drop both rays are again refracted. The other colors are formed by drops between the red and violet rays.

If we could look at the end of a beam of light, we should probably see some of its transverse waves vibrating from side to side, some up and down, and others at various other angles. Certain crystals, tourmaline for example, transmit only those waves which are vibrating in the same plane as the axis of the crystal. When light passes through such a crystal, we have polarized light. Polarized lenses are used widely by automobile manufacturers for headlights because the lenses stop the excessive glare from the lights. This enables people to see the sides of the roads better while driving at night.

Although a great deal is known about light waves and their characteristics, it is still a phenomena in the field of physics. There is still room for advancement and improvement in the field of light as in any other field of physics.

A woman saw an elephant in her yard and immediately called the police. "Chief," she said, "there's a queer looking animal out here in my back yard. He's picking flowers with his tail."

"Yes," said the sergeant, "and what does he do with them after he's picked 'em?"

"Never mind," was the answer, "you wouldn't believe me if I told you."

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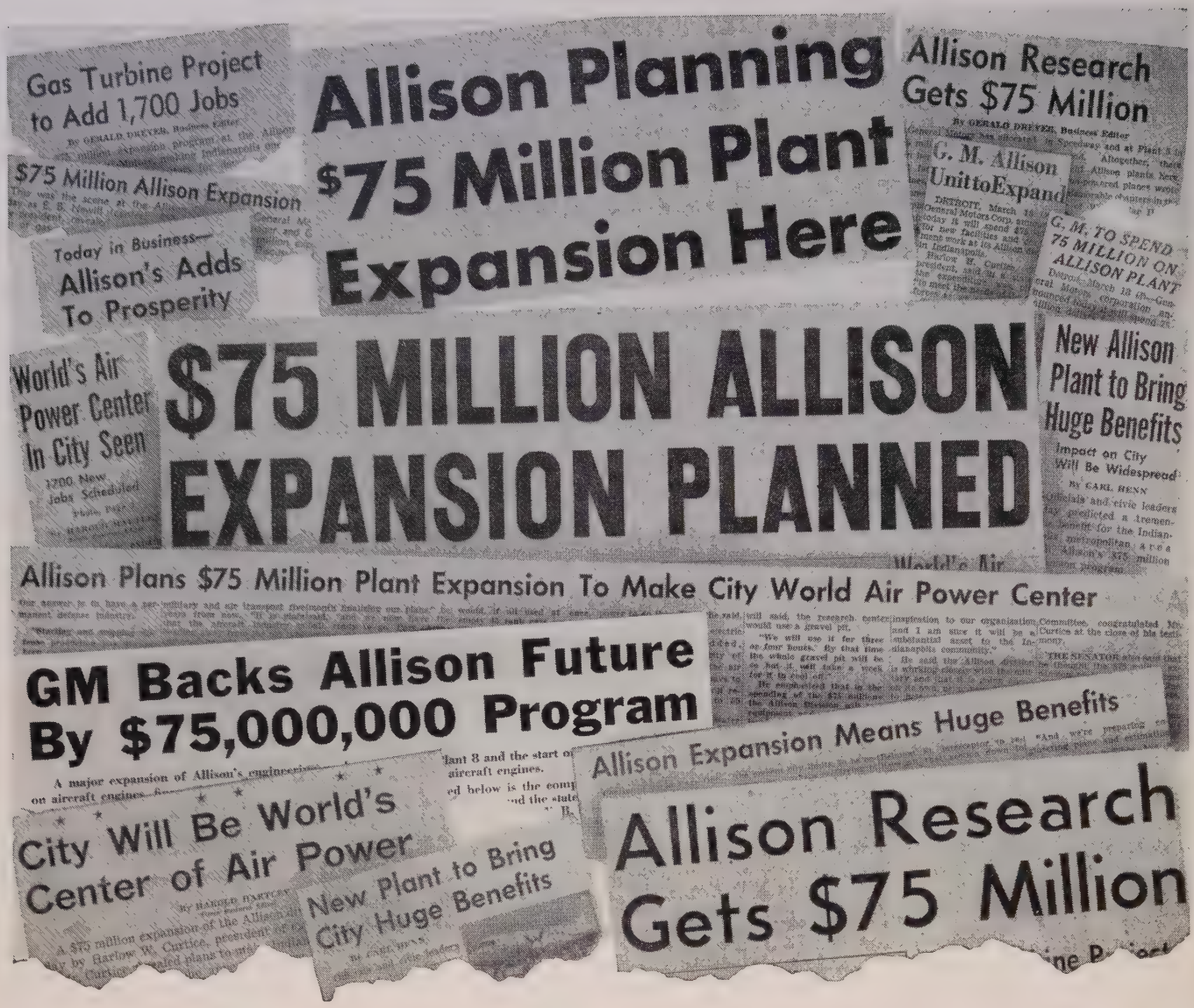
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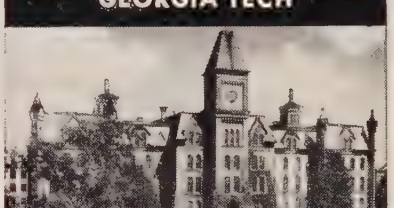

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From Push to Swoosh—

by ROBERT J. MARKS, Aero. E. '58

Ever since man has been on this earth, he has had dreams of being able to fly. This has been shown to us in Greek mythology by the famous flying horse, Pegasus. The Egyptians' sun god was a falcon. In Nordic legend, the Valkries rode winged horses and the Arabs had their stories of magic flying carpets. Several legends of man's early attempts to fly date as far back as 2000 B. C.

Through the years, men had many ideas of how to fly. The first really scientific step taken in aviation was by Archimedes when he established his law stating that floating bodies displace an equal volume of water. This principle is also extended to cover air. In the 1200's Roger Bacon published his book *Secrets of Art and Nature* and in it discussed a flying machine that could be made by taking a large hollow copper globe and filling it with "liquid fire." His definitions of this liquid fire were very vague and nothing ever became of his theory. It is recorded in Chinese history that balloons were sent up during the coronation of the emperor Fo Kien, but there is no real proof of this. Then, for over two centuries nothing was said or done about flying. Then, Lenardo Da Vinci revived the subject. He studied birds and their flight and in 1505 published a treatise on the flight of birds. Da Vinci formulated the principle that "An object offers as much resistance to the air as the air does to the object." Centuries later there were still many experimenters in flight that did not realize this important fact. He made many drawings of flying machines, many of which were patterned after birds. It is entirely possible that Da Vinci might have made some type of successful aircraft had he possessed a light-weight and powerful engine of some type. He even made sketches of a primitive parachute which he called a "fall breaker." A hundred years later, in 1648, Bishop John Wilkins published a treatise called *The Art of Flying* which was mostly pure nonsense. In 1670, a Jesuit priest, Francesco De Lana, proposed that a wicker basket be suspended from four large copper balls that had the air pumped out of them. He did not build the machine and therefore did not find out that the balls would collapse from atmospheric pressure. His reason, and very true, was that it would make wars even more horrible than they were at the time. Giovanni Borelli, in a treatise written in 1680, told the findings of his studies of the movements of animals. He showed that man is the weakest of all creatures for his comparative size. He pointed out that, even if artifical wings were contrived, a man would not have the strength to support his body in flight and that birds are definitely stronger when compared with man. Recent experiments have shown us that birds can draw on their reserve energy more so than any other creature on this earth.

It was because of Evangelista Torricelli's discovery in 1643 that air is a mixture of gases that really started the era of balloons. Because of his discovery, a search began in the 1750's for a gas that is lighter than air. In 1776, Henry Cavendish discovered hydrogen. Joseph Black, a Scottish professor, wrote his opinion that animal bladders filled with this gas would float. It was not until an experiment was made in 1771 that this statement was proven to be correct.

The first successful balloon was made because of a mistaken idea. The two Montgolfier brothers, Jacques and Joseph, saw the similarity between clouds and smoke and thought that smoke in light containers would float. As they were in the paper-making business, it was quite natural that their first containers were paper bags. With this arrangement, partial success was achieved on their indoor experiments. This prompted them to take their experiments outdoors. On June 5, 1783, they finally succeeded in sending a balloon up to about 1,000 feet. They then made a balloon out of silk which greatly exceeded the height and distance previously reached.

Their experiments attracted such attention that, in Paris, the Robert brothers made a balloon out of silk, under the direction of the famed physicist, J. A. C. Charles. This balloon was filled with hydrogen and on August 27, 1783, rose to a height of 3,000 feet and traveled over fifteen miles, all during a pouring rain.

The next Montgolfier balloon that went up carried animals as passengers. The ascent was made in Versailles in the presence of Louis XVI and his court. The animals, a rooster, a duck, and a sheep, were placed in a gondola attached to the bottom of the balloon. Louis liked the demonstration and wanted to send up a condemned criminal as the first man but the court historian, Jean Francois Pilâtre de Rosier, saw a chance to get his name written in history and begged the king to let him go up. This historic balloon was made of treated linen and was forty-five feet diameter and seventy-five feet high. During their experimenting, the brothers discovered that it was the hot air that made the balloon rise and not the smoke, so they placed a brass pan under the neck of the balloon that was filled with wool and straw which was burned in the air, thereby keeping the balloon in the air for a longer period of time. With this arrangement, De Rozier and a French courtier, the Marquis D'Arlandes, made a flight which lasted over twenty-five minutes and carried them over the city.

The Montgolfiers' rival, Charles, made a flight ten days later in the first hydrogen balloon. It stayed up for over two hours and flew over twenty-five miles from Paris. After this, the balloon craze spread like wildfire. People were even paying to go for rides in balloons. Scientific work with balloons also continued. On November 13, 1784, the first recordings of air pressure from great heights was made. On January 17, 1785, the first balloon crossing of the English Channel was made. The first

balloon flight in America was made on January 9, 1793, in Philadelphia by Francois Blanchard, one of the men who had crossed the English Channel. The first balloon casualty was when De Rozier's hydrogen balloon exploded as he was trying to cross the English Channel. He was killed immediately. After this incident, balloons were filled with coal gas, which is cheaper and safer.

Even from the start, many fliers tried to devise some way to control the direction of the flight. Along with the growth of the balloon the parachute was also developed. Sebastian Lenoramando, a Fernch physicist, is given credit for inventing the parachute. The first known jump made with a parachute was on October 22, 1797, and was made by Andre Jacques Garnerin over the city of Paris. Military uses were then devised for balloons during the Napoleonic Wars. Balloons were also used in the Civil War.

Because of the boldness of many of the aeronauts, there were many records made. Charles Green, the first man to use coal gas, flew 500 miles in eighteen hours in the year of 1836. In a balloon race in 1906, Alan R. Hawley stayed up for more than forty-six hours and traveled 1,355 miles. In 1927, Capt. Hawthorne C. Gray of the United States Army set the altitude record which still stands—42,470 feet in an open gondola. He was found dead in the gondola when the balloon came down, but the altitude was registered on his barometer. In later years new records were made in closed-cabin balloons. A height of 55,500 feet was made in the year of 1936. In 1935 the National Geographic Society and the Army Air Corps collaborated and sent a balloon, piloted by Capts. A. W. Stevens and O. A. Anderson, up to an altitude of 72,395 feet—a record that stood until the days of jet-powered supersonic flight.

Henri Giffard is the man accredited with the building of the first airship. He took James Watts' steam engine and combined it with Jean Meusiner's propeller and made a 144-foot airship. On September 24, 1852, he flew the ship from Paris to Elancourt at a speed of five miles per hour. This was the first completely-on-purpose flight made. Dirigible flight was brought to its modern level by a German, Count Ferdinand Von Zeppelin. The first successful Zeppelin was flown in the year of 1900. It weighed 25,000 pounds, including passengers and freight, and was driven at a speed of seventeen miles per hour by two sixteen-horsepower motors. In 1915, Zeppelin merged his company with that of his rivals, the Scheutte-Lanz, and proceeded to make Super-Zeppelins. One of these super airships, the R-34, was the first airship to cross the Atlantic Ocean. His most famous airship, and also the largest, The Hindenburg measured 811 feet, weighed 220 tons and had a volume of seven million cubic feet. It had a top speed of eighty-four miles per hour delivered by four 4440-horsepower diesel engines. Its cruising range was 8,750 miles. After seventeen trans-Atlantic flights, it crashed in flames at Lakehurst, New Jersey, killing 33 of its 105 passengers and crew.

The only airships in use right now are blimps. They are used mainly for advertising purposes and for observation purposes by the army and navy.

During the 1800's, two schools of thought were developed. One school of thought was that man could fly without any outside source of power. The other school of thought was that man would be able to fly in the future if some source of power were found. They were both partially right, but it was the work of the former group that started the progress of glider flight.

Otto Lilienthal is the man given credit for the first really successful glider flight. It was made from the top of a hill in Anklan, Germany in 1891. He made more than 2,000 glider flights with some of his longest being over 900 feet. When he was killed in a crash in 1896, he left his notes open for the public to use and benefit from. Percy Pilcher of England added much to Lilienthal's notes until he was also killed in a crash in 1899. After these two pioneers died, the spotlight on glider achievement was shifted to the United States.

Here, the acknowledged leader of aviation research was Octave Chanute. He made many flights at the sand dunes on Lake Michigan near Chicago. Chanute learned just about all that there was to know about gliding. He discovered that the most efficient gliders were biplanes. Since his time, most of the work done on gliders has been refinements in design but not new innovations. One of the longest glider flights made at the time was by his assistant, A. M. Herring. He made a flight at the dunes that lasted forty-eight seconds and traveled 927 feet.

The Wright brothers were also experimenting with gliders, and it was a great boon to them when Chanute turned all of his notes over to the brothers thus saving them months of time and effort. The brothers built their first great contribution to aviation—the wind tunnel. After much experimenting with different types of wings, they selected the one that had shown the best results and made a full-size plane using this type of wing. This time the brothers met with success. They made more than 1,000 glides that summer with some of them lasting longer than a minute and traveling more than 600 feet.

It was natural that the next step to take after gliders was some type of powered flight. It was, therefore, due to the Wright brothers' success with gliders that they became pioneers in powered flight.

On the morning of December 17, 1903, the Wright brothers decided that the weather conditions were just right at Kitty Hawk, North Carolina, and they proceeded to ready their queer-looking flying machine. It certainly was an odd piece of machinery that looked like a large kite. It had a body like a piano crate with most of the slats removed. The two graceful wings were tangled up midst the mess of bracing wires. There were two rudders, one vertical and in the rear for turning; the other, horizontal and held in front, to raise or lower the nose of the ship. In the center, a four cylinder gas motor was connected to two propellers. The plane was to land on two curved skids which were to keep the plane from overturning. With one of the brothers on board, it weighed slightly more than 750 pounds. Orville made the first trial which did get off the ground but was only up for twelve seconds and flew about forty feet. After two more unsuccessful trials by Orville, Wilbur took over and on his first trial achieved success. He flew a distance of 852 feet, stayed up fifty-nine seconds, and flew at a speed of about eleven miles per hour.

This first flight was not just a mad leap into space but had been planned for over one-hundred years previous and by many men. One man who possessed much foresight in this field was George Cayley of England. In his book, *On Aerial Navigation,* he stated that a solution to the problem of flight would be to make "a surface support a given weight by application of power to the resistance of air." He proved that he knew what he was talking about by making many successful model gliders. He was hampered only in the fact that he had no light-weight source of power as he was making his experiments in the year of 1809.

In 1843, Samuel Henson obtained an English patent on an "aerial steam carriage" of astoundingly modern design. It was a monoplane with a wing span of 150 feet and included movable elevator and vertical rudder! Substituting a gas engine for the steam and you have, in 1843, plans for an airplane containing features of modern aircraft up until the time of jets.

Modelmakers were so active that in the year of 1866 the Aeronautical Society of Great Britain was founded. modelmaking was being carried on in France, Germany, Italy, Austria, and the United States.

In the United States the most scientific work being carried on with models was done by Samuel P. Langley, direc

tor of the Smithsonian Institution. He developed models to such a degree of control that he could get them to perform three complete circles in flight. Langley came very close to building the first airplane capable of carrying man in powered flight. He built a machine with a fifty-two horsepower engine and on October 7, 1903, tried to catapult it from a houseboat on the Potomac River, but it failed to fly. After much repair, he made another attempt on December 8th with the same result. Nine days later the Wright brothers achieved success at Kitty Hawk. Whether it crashed because of flaws in the design or because it got caught on the supports of the catapult during both launchings is still a subject for a heated debate between students of aeronautical history. The first airplane fatality occurred in the year of 1907. Orville Wright was demonstrating one of his planes to the army at Fort Meyer, Virginia, when one of the propellers caught in a loose rudder wire and crashed, killing the one passenger, Lieut. Thomas E. Selfridge. In 1908, the army accepted the Wright brothers' plane, making it the first government-owned plane in the world.

The first woman ever to fly in a plane was the wife of a captain in the United States Army, Capt. De Ralph C. Van Deman. She flew as a passenger with Orville Wright on a test flight in 1909

The idea of crossing the English Channel was thought to be a great test for the fliers of the 1900's and seemed so difficult that the London *Daily Mail* offered a £5,000 prize for the first air crossing. On July 24, 1909, the flight was made by Louis Bleriot, who flew from Calais to Dover in twenty-five minutes. The flight was made in a 485 pound monoplane powered by a three-cylinder Anzani engine. The twenty-five horsepower engine weighed 143 pounds, delivered 1600 revolutions per minute and had a piston displacement of 205 cubic inches. It pulled the plane along at a speed of forty-two miles per hour.

The history of aviation would never be complete without some mention of Glen Curtiss. To enumerate his many contributions to aviation would be a complete story in itself, but it be said that he established many flying records, aided the army and navy in establishing their air forces, and, in general, aided aviation in many ways.

Another colorful character associated with making people air-minded was Lincoln Beachy, one of the most famous barnstormers in history. In his lifetime he made many tours with the Curtiss exhibition troupe. He was also the first American flier to loop-the-loop. He died on March 14, 1915, while stunt flying at the Panama-Pacific International Exposition at San Francisco.

The airplane was never so greatly improved as it was during the years of 1914 to 1918, during the first World War. The fuselage was covered, the tail assembly was completed, undercarriage landing gear was added, the efficiency of the airframe had been improved since Kitty Hawk about 200 per cent, the average speed had reached 150 miles per hour, and the engine now weighed about 1.9 pounds per horsepower. The attitude of the aviators in the war was that of ancient knights entering a joust or tournament. These light-hearted aviators fought for personal glory—the last of romanticists in war. Some of the aces in the war were Billy Bishop and Edward Mannock for England, Bob A. Little and Eddie Rickenbacher for America, and Baron Manfred Von Richtofen and Ernst Udet for Germany.

At the end of the war, there were many fliers who did not want to give up flying and therefore made attempts at many records. The first government mail service was started in May, 1918, between Washington, Philadelphia, and New York. The first scheduled airline in the United States was established between Key West, Florida and Havana, Cuba in 1920. Soon after the war, Commander Albert Cushing Read of the U. S. Navy, and his five-man crew took off to make an attempt to fly across the Atlantic and in 1919, succeeded in doing so. The flight took fifteen days and covered 4,500 miles. One month after this cautious Navy flight, two fliers took off and flew non-stop to Europe. Pilot John Alcock and navigator Arthur Witten Brown took off from Newfoundland on June 14th and landed in Ireland sixteen hours and twelve minutes later. They averaged 120 miles per hour for the 1,960 mile trip. In November, 1919, three flights were made from England to India. The same month, a flight was made from England to Australia, 11,130 miles, in 124 hours. In 1920, Lieut. C. C. Mosely won the Pultizer air race with an average of 178 miles per hour. Two years later, Gen. Billy Mitchell won the same race averaging 224½ miles per hour. That same year, 1922, Lieut. O. G. Kelly and J. A. MacReady set an endurance record by staying up for thirty-five hours and fifteen minutes. The following year, they flew the first non-stop flight across the continent, in twenty-six hours and fifty minutes. On July 3, 1924 Russell L. Maugham flew cross-continent solo in twenty-one hours and forty and one-half minutes.

In 1922 the U. S. Navy took a big step when they put a roof on the cruiser *Jupiter* and made the first aircraft carrier. This ship was renamed the *Langley*. In the following year, work was begun on converting two more battle cruisers. When these were finished in 1927 they became the *Lexington* and the *Saratoga*.

In the year 1924 preparations were made for the first attempt to fly around the world. The four planes making the trip took off from Santa Monica, Calif., on March 17th. Two of them landed in Washington, D. C. 175 days later. The flight covered 25,000 miles and the two ships which finished consumed 19,200 gallons of gasoline and 4,800 quarts of oil in a total of 320 hours and 19 minutes flying time.

Another great not to be forgotten in the history of aviation is Charles A. Lindbergh. Probably he is best known for making the first solo flight from the U. S. to Paris. He accomplished this flight of 3,600 miles in 33½ hours.

On the eve of World War II many impressive records had been made. A speed record of 469 miles per hour was set by a German pursuit plane. The record for non-stop flight was then the impressive figure of 7,150 miles. Airlanes recorded an impressive figure of 73,267 miles. Planes had also reached the altitude of 41,794 feet and were still climbing.

It is doubtful if the airplane was of any great importance in the first World War, but it was very definitely a deciding factor in World War II.

A few weeks before the invasion of Poland by Germany, the Germans made the first jet flight in a Heinkel He-178 with a Heinkel S3B turbojet. The idea of jet flight had to be abandoned by the Germans at that time because of limited production capacities of their country. They decided to concentrate their efforts on single-seat dive bombers to put across their "lightning war" or *blitzkrieg*. The Germans were soon pushed back by the English because of the superior air power of the British.

The British planes and men were greatly outnumbered but in this sort of fighting they had the advantage. Their talent for producing great pilots and faster planes soon forced the Germans to back away from daylight raids. The development of 100-octane gasoline also gave their planes much more speed and power than the Germans could boast. The fact that the Germans could not capture the Baku oil fields in Russia or the Arabian oil fields in Africa led to a shortage of gasoline which in turn grounded most of the German air force. This fact is thought to be very decisive in our victory over Hitler.

Meanwhile, the United States was struck a crushing blow when, on December 7, 1941, Japan attacked Pearl Harbor. This threw America into one of the most bloody wars in history. Our airplane production was pushed up ahead of everything else so that we could catch up to the progress that the Germans had

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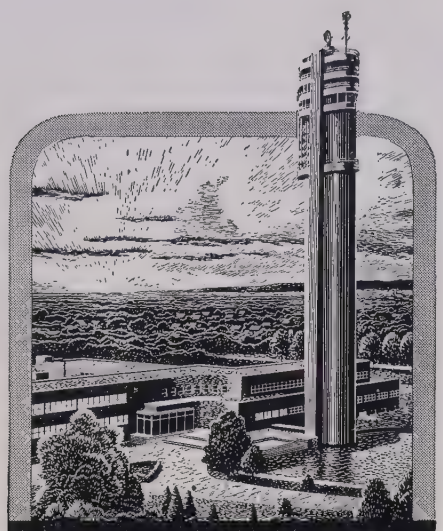

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made. We concentrated on the fighter and the dive bomber of which they had so many; but from the first, the U. S. high command was thinking of long-range high-altitude bombers. Generally speaking, the British preferred what is called saturation bombing—which means just what it says. The whole area is simply saturated with bombs. American bombers, on the other hand, favored precision, pin-point, or strategic bombing, with the bombs dropped on definite targets. In this manner, most of the key German industries were put out of commission.

On April 18, 1942, Col. James Doolittle made a vast sweeping raid on Tokyo, Kobe, and Osaka. The losses were high and the military results negligible, but the main object of the raid was accomplished—to boost American morale and to cause the Japanese to lose their treasurer "face."

Toward the end of the war, thousand-plane raids were fairly common, including 600 B-29's. The Japanese war machine fell apart under such pounding. In July, one month after Germany surrendered (June 8, 1945), Japan sued for peace. The Allies asked for unconditional surrender but the Emperor would not accept this. Then, on August 6, 1945, an airplane was used to drop the most cruel weapon man has ever conceived—the A-bomb. More than 60,000 persons in the city were killed, more than four square miles burned out, 62,000 of the 80,000 homes were flattened —all from one bomb! The Atomic Age had begun with foreboding and dread. But this was not the end. On August 9th, the seaport of Nagasaki was hit with another A-bomb and the result was the same. The following day the Japanese government sued for unconditional surrender.

The evolutionary chain of gradual improvements in the airplane was broken with the coming of jets and rockets. A jet or rocket works on the principle of Newton's third law of motion, "For every action there is a reaction." The simplist application of this principle is seen when air escapes from the open neck of a balloon. It isn't the force of the air escaping that drives the balloon but the pressure set up against the closed end of the balloon. The big difference between rockets and jets is, a jet must have a place for taking air in at the front and for expelling gases at the rear, while a rocket must carry its own fuel, as a jet does, and also its own oxygen as rockets must fly where the air is very thin, or, at least theoretically, where there is no air at all.

The first jet flown in the U. S. were flown in 1942. They achieved speeds of around 600 miles per hour. Since the speed of sound is 780 miles per hour, at sea level, the designers began to dream of supersonic flight. The first such flight was made on October 14, 1947 by Charles Yeager in the Bell XS1, a rocket ship. It flew at speeds of more than 1,000 miles per hour. In the meantime, the U. S. Air Force had enough Lockheed P-80 Shooting Stars to start training squadrons of jet pilots. In June, 1951, a Douglas Skyrocket, an experimental rocket plane, set world records for speed (1,238 mph) and altitude (70,000 feet).

The British were also early in their jet development, having flown their first jet on May 15, 1941. Although the Germans actually had a jet plane in the air earlier, the engine used was a type shortly abandoned, and therefore the British hold the claim of having the first *successful* airplane to use a gas turbine internal-combustion engine. The British also hold the distinction of having made the first jet airliner in the year of 1952.

As was stated previously, the Germans were the first ones to fly a jet plane. This was done on August 27, 1939. All through the war the Germans were doing some work on jets, but most of their time was side-tracked because of the need for other planes in the war. Towards the end of the war, however, they managed to bring some of their jets into action; and if the war had lasted any longer, the Allied supremacy in the air would have been a questionable thing.

Robot planes, guided from aircraft carriers to Communist targets in Korea entirely by electronics, were introduced by the U.S. Navy late in 1952. On the basis of their experiments with this type of aircraft, the Navy later predicted that robot bombers carrying atomic bombs could conceivably hit any target in the world.

The U.S. was not the only one with airpower in Korea as they were met by Russian MIG's. When one of them was shot down in 1951 the world knew that the Soviet Union had a jet fighter that was second to none.

Thus, in the short fifty-odd years since the Wright brothers flew at Kitty Hawk, man has made the world seem even smaller. Powered flight has brought about more changes in a man's lifetime and has more far-reaching results economically and socially than possibly any other event in the history of the world. Even nearer draws the day when an atomic-powered plane will be able to circle the earth in a day. For good or evil, man has added another dimension to his travels and by changing our concepts of time and distance, aviation has changed man's relations to the sphere on which he lives. This is an era in which, literally, "the sky's the limit."

THERE IS NO END TO THIS STORY.

Above . . . 500 Megacycles

by David L. Komyathy, E. E. '57

Microwaves were the first-made radio waves; these waves were originally made by Heinrich Hertz, in 1888. Hertz's waves were two feet long with a frequency of 500 megacycles. (Modern microwaves are in the range of one-quarter of an inch to two feet long). It is interesting to note that while the first radio waves were microwaves, it wasn't until over sixty years later that microwaves were considered worth anything in radio. The physicists and engineers who deevloped from Hertz's discoveries the beginning of radio went quickly from microwaves to longer wavelengths. The reasons for this were that microwaves could be transmitted only to the horizon and it was very much harder to generate large powers at the microwave lengths than at long wave lengths.

In order to understand microwaves we must visualize their lengths. The behaviour of waves is governed by their size in relation to the dimensions of things with which they interact. Light waves are so small that almost any object we think of is large in comparison. Therefore, most objects cast a distinct shadow. The waves of a broadcast radio are about a quarter of a mile long. They will flow around a small hill casting very little shadow. Because the transmitting antenna which sends out these waves is small compared to the wave length the waves are transmitted in all directionse; it takes an antenna many wavelengths in size to focus waves. Microwaves, however lie in the range of most common objects. With a small wire microwaves can be broadcast in all directions; with the dishpans, as the reflectors are called, the microwaves can be focused in a narrow beam.

Since these waves are moving at 186,000 miles a second, one may wonder how they can be measured. The method used is a simple one which was developed by Hertz. The waves are reflected straight back and standing waves are produced. A quarter of a wave length from the surface the crest of the reflected waves meets the crest of the incoming waves. Here the combined crests give a strong signal. Half a wavelength away the crest of a reflected wave coincides with the trough of the incoming wave producing a weak signal if any at all. By determining with a detector where these positions are the wavelengths can be easily measured. Standing wave measurements are used in developing devices which are meant to absorb instead of reflect microwaves.

Microwaves are trnsmitted by means of concave mirrors, lens type antenna, or horn shaped antenna. To act as a directional antenna the mirror must be shaped just right so that the waves sent along form various points of the mirror have their crests together and add up. The horn antennas are used like megaphones. The signal comes in the small end and leaves almost uniformly out the large end of the horn. If the large end of the horn is many wavelengths in diameter, the beam sent out can be very narrow.

Ordinary types of electrical transmission lines cannot be used to run microwaves into the equipment. Lines act effectively as antennas and radiate the electromagnetic power into space, instead of conducting it into work. Wave guides must be used for conducting the microwave electromagnetic power. These consist of actual copper pipes, highly refined, with silver plated interiors and, in some instances, are special glass filled affairs. These hollow pipes act as conductors of the microwaves or project them from an open end.

The microwave system was highly developed during World War II for the transmission of messages from point to point. It can be used in relaying, telemetering, supervisory control, and communication. A large number of quantities can be transmitted on a single beam, thus cutting down the number of channels of communication needed.

Since the microwaves are short wave

Here is an example of a microwave tower with the facilities for relaying located at the bottom of the tower. There are two receiving and transmitting antennas.

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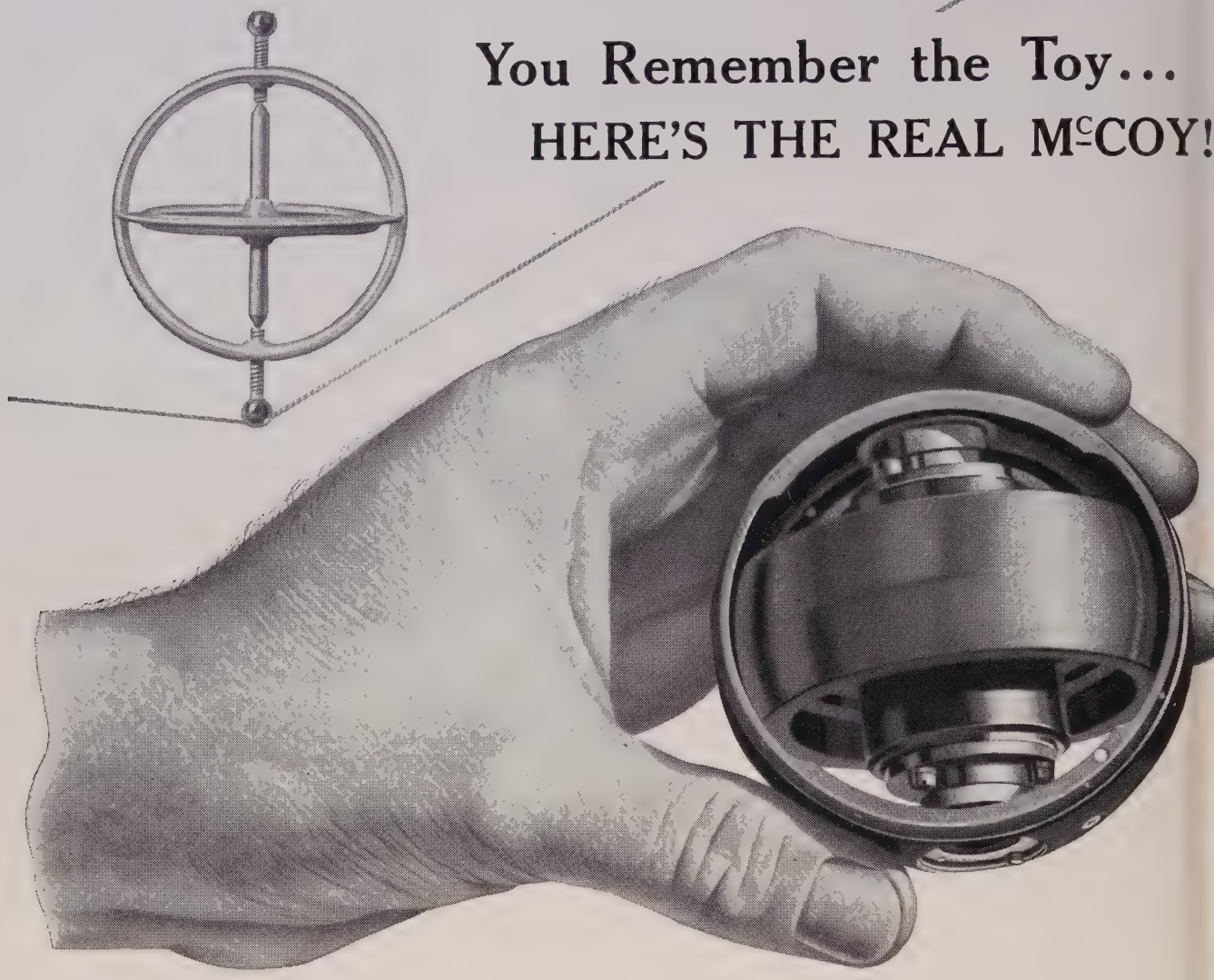

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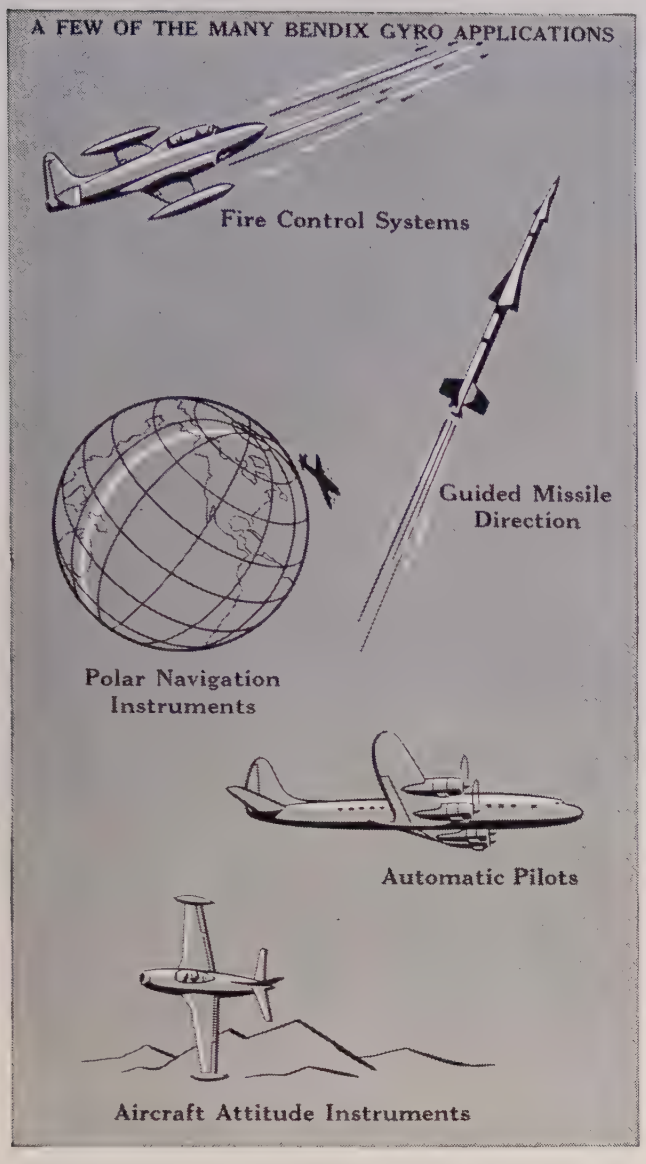

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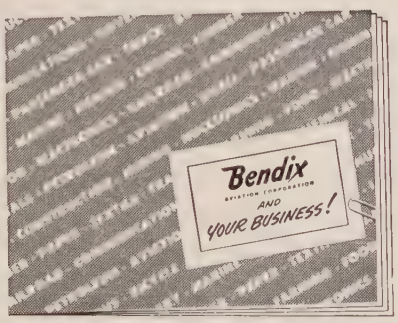

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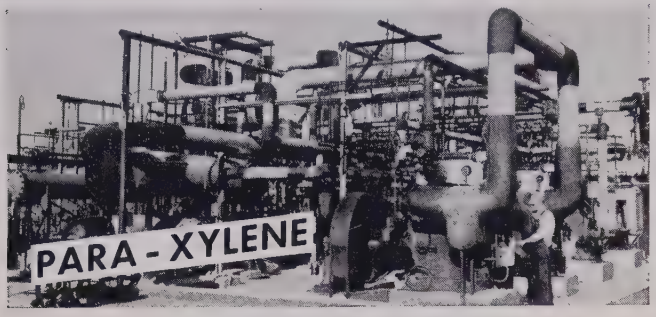
Below Right: Three of the six Frick refrigerating machines in service at Big Spring, Texas.



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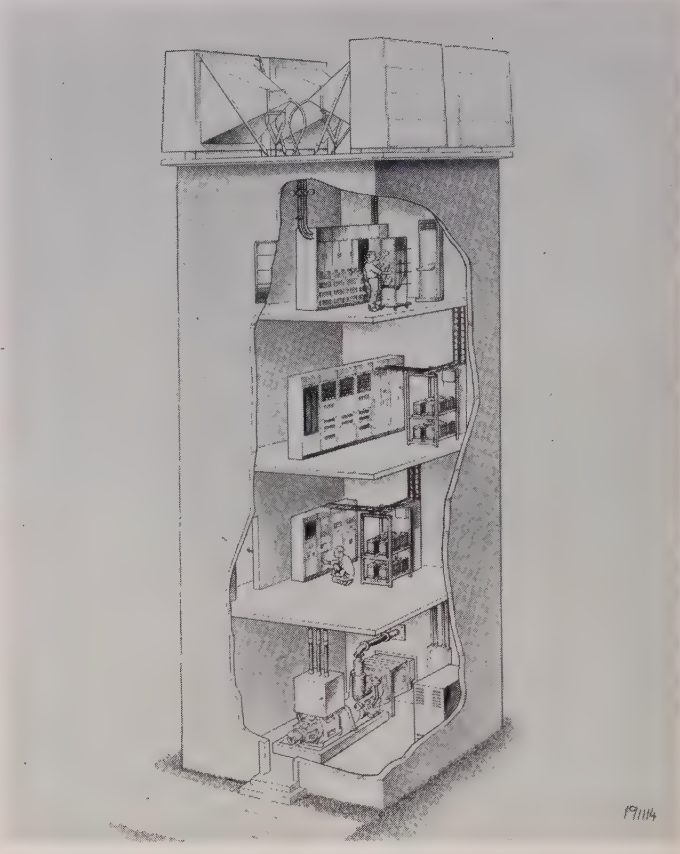


This relay tower, with the relaying facilities located in the tower proper, is similar to the ones used in the TD-2, the relay system employed by the Bell System. The power facilities are located at the bottom and the bays of receiving and transmitting equipment are located on the upper floors.

lengths and travel like light, interfering objects block the line of transmission. Because of this, much depends on the line of sight between towers for transmission. Since the earth curves, the distance between transmitting towers must not be too great. Between two 200 foot towers it is possible to transmit 35 miles. Two 100 foot towers are good for 20 miles and one 200 foot and one 50 foot tower are also good for 20 miles. For this reason the towers are usually placed on as high ground as possible.

The number of microwave channels able to be used depends on three factors:

1. The line of sight characteristic
2. Angular direction characteristic
3. Frequency selection.

Fifty miles away from a given installation the line of sight on a straight line for the tower would be 1650 feet above the earth and the same frequency the other tower had could be used over again. The entire spectrum available to the microwaves could be used in each 100 mile square area. Many channels could be used at the same frequency because of the directness of the pattern; i. e., fairly high degree directional antennae are used. Using a conservative figure of twenty degrees, four signals could be sent in four directions from a given point without interfering with each other, discounting reflection from buildings, etc.

There are a great many advantages which can be listed for microwaves. A microwave is as reliable as the atmosphere through which transmission takes place. It is not dependent on pilot wires or the continuity of transmission line conductors. Microwave channels would not be subject to the same degree as transmission lines to conditions such as sleet, windstorm, airplane damages, etc.

The intelligence required by a large number of different functions can be transmitted on a single microwave channel using modulated subcarriers. The maximum number of channels which can be provided is dependent on the type of multiplexing equipment used.

Interference in the microwave band is very small and may even be a negligible factor. This works in the sense that microwaves won't interfere with other facilities and other facilities won't interfere with the microwaves. An exception to this would be obstacles in the path of the waves such as an airplane coming directly between two towers. Rain and snow do not affect the lower frequencies. Above 10,000 megacycles they may suffer absorption and refraction by the atmosphere.

Since the microwave channels and terminal equipment are independent of the power system, maintenance can be performed without the necessity of having any part of the power system out of service. This simplifies and makes safer the repairing where maintenance of a coupling capacitor of the line trap is necessary.

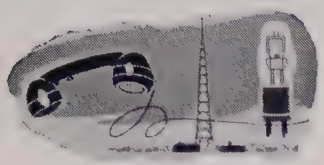
A well designed microwave system provides an extremely flat frequency response even though the signal must pass through many relay stations in tandem. This gives a superior voice quality.

Power line carrier systems must often use the same frequency in both directions to conserve spectrum. This requires use of a push to talk switch. Standard microwove systems permit simultaneous two way transmission.

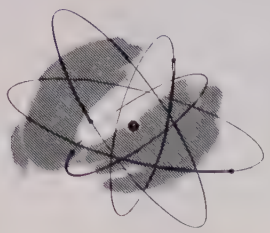
In contrast to the crowded carrier spectrum, the microwave spectrum is tremendously wide.

Everything doesn't work to an advantage in the microwave system for it also has several disadvantages. With the high voltages necessary it means that an a-c power supply will be needed with the present equipment For some uses this is no disadvantage but in relaying, where reliability is important it will be necessary to use a continuous d-c to a-c power supply unit in order to use station battery power. In other cases it

12 of the basic industries in which Bendix products play a vital role



ELECTRONICS

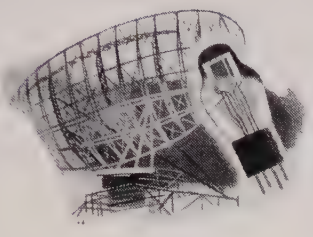


ATOMIC ENERGY

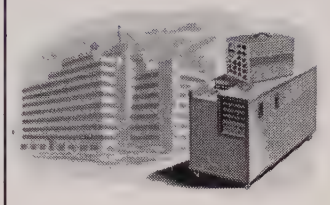
AUTOMOTIVE

AVIATION

GUIDED MISSILES



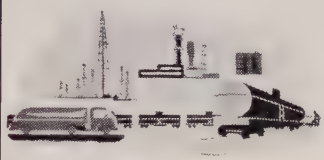
RADAR



COMPUTERS

MARINE

RAILROAD



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This is also one of the types used by the Bell System, showing the view from the outside. The size of the tower can be compared with the cars and telephone poles located along side of the tower.

will be necessary to have transfer equipment to go on battery in case of an a-c power loss.

Since the beam is so directional, rigidity of the structure is important and the cost may be high for one of that type. However, with a fairly broad beam deflection is not too important.

When there is trouble in a part of carrier only one channel of communication is usually affected but in the case of microwaves, if part of the multiplexing or radio frequency equipment goes bad, many channels may be knocked out. This can be eliminated as longer life tubes are developed and by the use of duplicate set-ups.

Perhaps the most well known application of microwaves is that of relaying. In locations where a large number of circuits exist between two points a microwave channel may be used to convey the intelligence. Under this category would fall those stations which use power cable, where the use of carrier equipment would not be possible.

A microwave channel provides an ideal means of transmitting a large number of quantities desired.

The company which probably has gotten the most out of microwave relay systems is the Bell System, through its parent organization, American Telephone and Telegraph. At the end of 1952, Bell System had completed 6000 miles of their system, which is called the TD-2. The TD-2 is the most extensively used in the world. Both telephone and television signals are transmitted.

A. T. & T. constructed its first multiplex microwave relay system between New York and Boston. This system was known as the TD-X and it was placed in service in 1947. It has been used ever since for the regular transmission of television. It operates on the frequencies between 3900 and 4200 megacycles. Two channels are beamed in each direction. The TD-X was also used for a telephone transmission trial during which a pair of radio channels satisfactorily carried 240 simultaneous telephone conversations.

Microwaves in the TD-2 are beamed by lens type antenna. The average distance between stations is about 30 miles. By making use of hilltops, greatest height possible is obtained for the towers. The TD-2 can provide six wide band radio channels in each direction over a given route. To obtain this, the 500 megacycle band was divided into twelve channels with forty megacycles separation between centers. Each band is twenty megacycles wide with a twenty megacycle guard band. (On a spur route almost parallel to the main route, the guard bands are used as the channel frequency reducing possible interference between the two routes.)

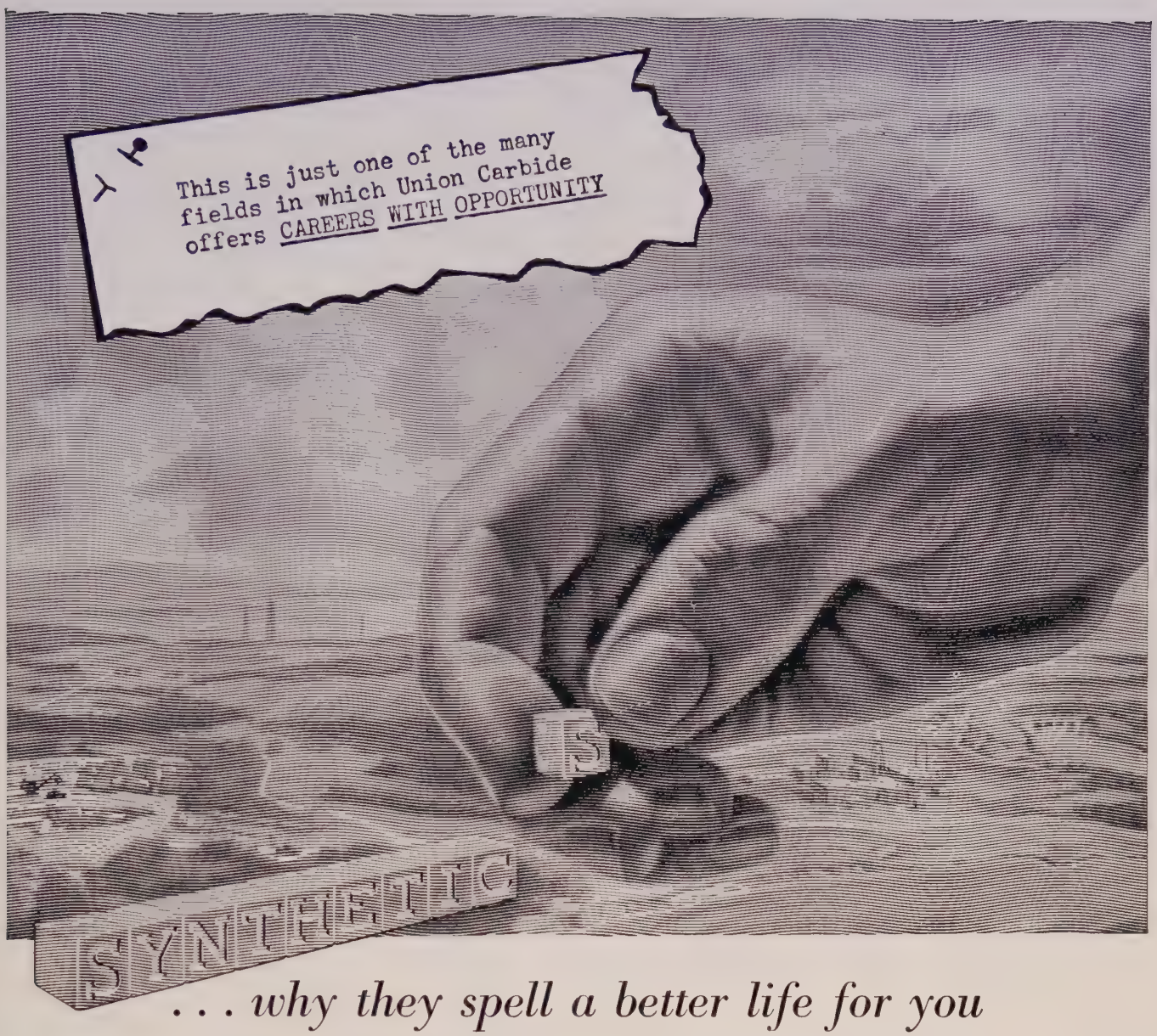
The frequencies used for transmitting and receiving are alternated station by station. Thus, station "A" would be receiving at 3730 and would transmit the same intelligence at 3770. Station "B", receiving at 3770, would transmit at 3730. This way, possible interference between receiving and transmitting signal is eliminated.

In the TD-2, each relay station constructed has facilities for handling six radio channels. At the relay stations, each channel requires its own bay of radio receiving and transmitting equipment. Combined energy of the six channels is picked off by the antenna and it is transmitted through waveguide filters at the top of repeater bays, each of which picks off its own channel frequency and passes the other with negligible loss. Similar filters combine the transmitted energy.

Each of the individual radio channels is capable of providing a television channel with a band width greater than eight megacycles. These channels can be used for transmission of one television program or 600 telephone circuits using the same multiplexing systems that are used in the coaxial cables. Since one of the six available channels is kept in reserve, using five channels, the TD-2 system can provide ten television circuits (five each way), 3000 two way telephone circuits, or any combination of the two.

Another application of microwaves, entirely different from communications, is that of heating. Industry uses the microwaves in dielectric heating for drying dyed cloth, printed cloth, and paper, for curing, or for setting resins or glues. Using flexible wave guides, a flexible hose with a divergent taper at the end of it could be used to spread microwave energy over a large area making possible a microwave stove. The Radarange, made by Raytheon, utilizes this type of construction. The commercial model was engineered and designed primarily for extremely rapid cooking for drive-ins and other similar places. It cooks a hot dog in fifteen seconds and raw hamburger and onions in 35 seconds. The input power for this stove is 4½ kw at 115 volts, 60 cycle, 40 to 45 amps, or 230 volts, 60 cycle, 20 to 22½ amps.

It seems that the future for microwaves is unlimited. Already they play an important role in our daily life.



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The Chemical Engineer in a Consulting Organization

What are the opportunities for a chemical engineer in a consulting group? What are his chances for advancement? How does the job compare with one in a specific industry?

I will try to answer these questions in a general way and can perhaps give you a picture of what some of the factors are which might help you to enjoy your job, and some of the principles which might help you to succeed in it.

One way in which consulting work may differ from that in a specific industry is that the former involves great variety. Consulting engineers may have to design and install a plant for making peanut oil or tung oil alternatively —as we did on the Island of Madagascar—or may have to design a plant for the separation and purification of magnesium—a job we also have done. Actually, the work itself is not essentially different whether done in a consulting group or in the laboratory or drafting department of a chemical manufacturing firm. The set-up is much the same; the demands on the technical ability and need for personality adjustment and cooperation are similar.

Some consulting groups are relatively large, some small. Advancement in either case depends largely on the individual, his interest in his work, the drive he puts into it, and his willingness to accept and meet responsibility. One way of demonstrating this spirit is by consistently doing a little more than is actually demanded.

Whether to take a job that has been offered should be decided chiefly by whether you think you will *like* the work. If you really like your work, it will prove a challenge and hold your interest. Then you will want to keep it, and advance in the company as your experience warrants it.

The Salary Question

Salary should, of course, be "the going" rate for your training and experience. It is not necessarily the dominant factor in a job offer. If salary is your first criterion, you should probably try to get into sales rather than into technical work.

A survey of the incomes of American Chemical Society members for 1950—these include both chemical engineers and chemists—showed that people in these professions make fairly good salaries which vary with the particular job classification. Of twenty-one categories, only four showed a higher percentage of people getting \$6,001-\$10,000 than those getting \$3,001-\$6,000. These were for people employed in patent work, sales, consulting, and administration.

In all other classes of work, such as research and development, plant operations, plant control, teaching, and government employment, the largest number employed in each was at the \$3,001-\$6,000 salary level.

Patent work is highly specialized, requiring both technical and legal knowledge, and an interest in careful and accurate phraseology. A high percentage of patent attorneys are in the upper salary brackets. Sales work demands technical knowledge, pleasant personality, drive, and persistence. In consulting work, a good technical background is highly important because the consultant is selling services. He has to get results and get them with a good measure of economy. In other words, he must be a good business man as well as a sound technical person. Administration is always the most highly paid work because it involves determining broad policy and supervising—sometimes closely, sometimes remotely—the work of others. More than half of those reporting as employed in industrial administration got over \$10,000 a year.

The Position of Management

No beginner is going to be high in the administration of a company. He needs experience and he has to add a great deal of real learning to the training he received in college. However, those at the top are always looking for good younger workers to grow into position of leadership and so share in the general management picture. As soon as an engineer or chemist has one person under him whose time he is responsible for, he becomes a part of management, even if it is only the person who washes glassware. Every ambitious young person should aim at reaching some degree of supervisory responsibility as soon as possible.

The supervisor at any level has the privilege of giving instructions—often called orders but preferably phrased as suggestions. The responsibility is to see that the instructions or suggestions are clearly enough worded so that they will not be misunderstood and that the person to whom they are given is capable of carrying them out. Don't tell a draftsman to figure the manufacturing costs of a plant when he only knows how to make the drawings for it.

Good management is important in any industry but it seems as though it is especially important in a consulting organization. Management has the doubtful privilege of deciding how, where, and when work is to be done and the responsibility of seeing that the how is feasible, the where physically adequate, and the when attainable. In short, the responsibility for getting results ultimately devolves on management and no "General blamed the Colonel, Colonel blamed the Captain, etc." will serve.

A privilege of management is that the leadership which carries the responsibility of setting a good example in every way, and in particular of conferring with such assistants at such intervals as are necessary to provide that leadership. Management has the privilege of determining policy, particularly with respect to personnel relations and then is definitely responsible for seeing that policy is followed and personnel kept happy.

The responsibilities of management outweigh the privileges. Some men take the privileges delegated to them, then try to have someone else take the responsibility, notably by checking every point with the person to whom they report. Such people do not last long.

Let us see how one does research. We all do it in basically the same way. We get together what we think are a number of competent group leaders. We assign them what we believe are adequate personnel. We define the objectives to be attaind, we cooperate on the plans for carrying out assignments, and we give guidance as the work progresses. It is then the duty and responsibility of the group leaders to do or have done the day-to-day job of preparing set-ups —I mean of equipment rather than the liquid variety—conducting the laboratory work, making observations, entering records, writing progress reports, and drawing conclusions. They, the group leaders, *must* cooperate, collaborate, and coordinate.

Management would like to select competent people and then give them their problems and their budgets and sit back and have things roll along. That's idealistic, but unrealistic. Results

have to be evaluated to see whether a particular group is getting anywhere on their problem or problems. Guidance has to be given. It has to be given in such a way that the guidee feels that it's only guidance, not instructions. Nothing kills initiative quicker than instructions of exactly what to do and how to do it. Technical people have to be listened to sympathetically and encouraged when the going is rough. Overenthusiasm when things go well must also be minimized so that the swings from enthusiasm to discouragement will be lessened.

Any research organization, consulting or otherwise, is neither better nor worse than the sum of the knowledge, experience, and capabilities of its total personnel.

As a matter of management the research group is the basic unit. Possibly in consulting, we give more authority to the group-leader level than does the average executive in industry. I use group leader as a descriptive term; there are varied titles used within different industrial organizations for the person at that level of responsibility. Actually this is a person who has from one to ten people working under him. The workers are assigned laboratory space and do the actual operations. The degree of supervision naturally coorelates with the particular work assignment and with the degree of experience of the worker.

Periodically I tell our group leaders: "You must so handle your assignments that you get the maximum of productive effort, the optimum of results." Theoretically the exact hours kept are not of first importance; practically it's bad policy to make exceptions as it creates hard feeling among those who may feel less privileged. The ideal research man is his own boss. He finds it harder to please himself in terms of results than to please management. He wants to get the facts, and to know what his results show; in other words, he becomes interested in the problems for their own sake. Therein lies the answer to creating scientists, whether they work at a lab bench, in a pilot plant, or do desk work.

Not all men advance at the same rate. The most valuable men are not necessarily those who advance most rapidly. Steady progress is better than the brilliant advance which can't keep up. To look at it from a different angle, the "genius" is often a problem child. A few years as a member of a group is followed by a year or two as a strawboss to break in on managing at the group leader level.

A man should segregate his personal likes from his research to a reasonable extent. That doesn't mean that he should not ever discuss his work at home or his home at work. It does mean that his wife's, children's or girl friend's tantrums or illnesses or perversities should interfere with his work no more than a reasonable amount. Over the years I have had a secretary fall in love and another one get religion. In those particular cases the results were fatal to production.

There's on type of engineer we can do without—the flash-in-the-pan type. He accomplishes one result of greater or lesser significance. His company adopts it—if a product, usually a minor one—then the inventor expects to repose quietly on his derriere for the rest of his useless life. The chemical engineer we want finishes up one accomplishment and goes on to the next.

We have to live with our fellow man. Engineers too must be capable of doing so. Therefore, the workers all of us are looking for are pleasant and tolerant of their fellow man. When I say that a worker must be tolerant, I mean tolerant of others' opinions, not of the legal triumvirate race, creed, or color, although that kind of tolerance is desirable. More specifically, a man may have an opinion as to a product, process or reaction. But if he tries to defend that opinion instead of being open to adverse opinion, subject to experimental proof, he may find himself defending an obsolete position while others go on. Perhaps it is best expressed that he must have a belief in and respect for the intelligent and intelligence of others as well as his own.

In technical thinking, a good worker must be logical. He is preferably but not necessarily logical in other thinking. This leads inevitably to his not being willing to accept anything fully until he can examine it by logical processes of reasoning and prove it experimentally.

Imagination is necessary. A worker must recognize a desirable result when he sees it, even if it is not what he started out to get. I do not mean that an unsuccessful pancake flour can be expected to be a good adhesive. But an attempt to produce milled toilet soap in a rubber mill gave the U. S. our most widely used process for making floating soap, while milled soap is still made the same old way with minor variations.

A man must continue to learn throughout his professional career. Just recall that a man who stopped learning in 1940 would today know really nothing about antibiotics, atomic fission, or benzene from petroleum. All of you must have a curiosity about what will be new in 1960. We don't know what it will be but we know it *will* be. We want that type of person.

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'actory testing of U.S." electrical wires and cables

CABLE TESTING (Part I)

It has been indicated in a previous section of this series entitled "Cable Specifications" that practically every element of insulated electrical wires and cables may be covered by some specification requirements. Numerous tests are, therefore, necessary to determine the suitability of such cables for the application for which they are designed. These tests may be conducted on (a) the cable elements during manufacture, known as preliminary tests, (b) the completed cables at the factory, final tests, and (c) after installation. Some of the preliminary and final tests at the cable factory such as conductor resistance, high voltage, insulation resistance and corona level are, generally, non-destructive tests and may be conducted on each entire length of cable manufactured. Other tests, such as insulation and sheath thickness, physical, aging, moisture, resistance, ozone resistance, capacity and power factor, short-time dielectric strength and cold bending and long-time dielectric strength tests are made on short samples selected from a lot of cable.

No. 9 in a series

The following is a general description of these tests and the significance as applied to insulated electrical wires and cable Details of the test equipment required and the specification requirements are not discussed since they are covered by industry publications such as those of the American Society for Testing Materia and the Insulated Power Cable Engineers Association.

FACTORY TESTS

Factory tests are performed for the following purposes: (1) determine whether the materials of which the cable is made ha the required quality; (2) to determine whether the manufacturi processes such as wire drawing, annealing, compound mixing, ins lation extrusion and vulcanization have been performed properl (3) to detect partial or incipient faults that may have accidental failed to be detected in the tests indicated in (2); and (4) to dete mine whether the cable meets the customer's specifications.

Tests on Entire Lengths

CONDUCTOR RESISTANCE. Test is made to insure that the conduct has the required average cross-sectional area and, hence, that i resistance does not exceed the allowed maximum.

SPARK TESTING. The entire length of insulated conductor is su jected momentarily to a high potential to detect and permit th repair of imperfections in the insulation that might cause failu on subsequent voltage and insulation resistance tests.

HIGH VOLTAGE TEST. This test is conducted on each entire length insulated cable to detect potential faults or weak spots in the ins lation and to insure that the insulation will withstand the minimu voltage required by the specification for its rated voltage. The ma nitude of the test voltage is determined by the type and thickne of the insulation as shown in the following table for 600 volt cable The time of application is one minute for code grade insulatio and five minutes for the higher grades.

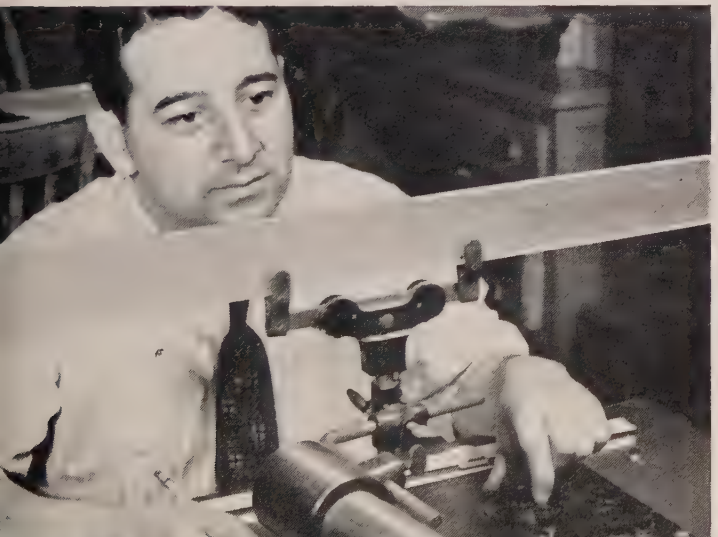
Insulation Thickness and Test Voltage for Rubber Insulations for 600 Volt Service

Conductor Size, Awg or MCM	Insulation Thickness, 64ths Inch	Code Grade	AC Test Voltages Performance and Heat-Resistant	(KV) Ozone Resista
14 to 9	3	1.5	3.0	4.
8	4	1.5	3.5	6.
7 to 2	4	2.0	3.5	6.
1 to 4/0	5	2.5	4.0	7.
225 to 500	6	3.0	5.0	8.
525 to 1000	7	3.5	6.0	10.
Over 1000	8	3.5	7.0	11.

Cables designed for operation at voltages above 5001 are requir to withstand a d-c test voltage in addition to the a-c voltage. Th d-c voltage is three times the a-c voltage for ozone-resistant ins lations and it is usually applied for 15 minutes.

The high voltage test is made by applying the required volta between the conductor and water in which the cable has been i mersed for at least six hours. When metallic coverings are prese the voltage is applied between the conductor and such coverin Any failures are repaired and the cable again subjected to t voltage.

NSULATION RESISTANCE. The insulation resistance test consists of pplying a direct voltage of from 125 to 500 volts, usually from a attery, between the conductor and water in which the cable is mmersed, or other ground, and measuring the current that flows hrough the insulation after an electrification of one minute. A uitable galvanometer is generally used for this measurement. From his current and the applied voltage, the resistance of the insulation calculated and expressed, usually, as megohms (1 million ohms). his test is conducted after the voltage tests and, hence, serves to ndicate whether the insulation failed on that test. Insulation resistnce also serves to indicate uniformity in processing, particularly



insulation compounding, since a well-processed compound shou give reasonably uniform insulation resistance. Most wire and cab specifications contain minimum requirements for insulation resis ance so that this test determines whether or not the specification complied with.

The resistance of insulations is inversely proportional to the ter perature, that is, it is lower at high temperatures. It is, therefor necessary to note the temperature at which the insulation resistan is measured and to apply a correction factor to reduce the resistan to a standard temperature. The insulation resistance varies with t type of insulation, its thickness and the size and length of the co ductor. The following formula gives the relation between the factors.

$$\text{Insulation Resistance, Megohms} - 1000 \text{ feet} = K \log_{10} \frac{D}{d}$$

Where, D = Diameter over the insulation, inches
d = Diameter over the conductor, inches
K = A Constant for the insulation used

CORONA OR IONIZATION LEVEL. This test determines the volta at which ionization or corona develops in a length of cable and usually made only on cable for operation above 4000 volts. It made by applying a gradually increasing a-c voltage between t insulated conductor and water or other ground with an oscilloscop in the circuit. Any air entrapped at the surfaces of the insulation within the insulation will ionize when a sufficiently high voltage applied resulting in the formation of more active oxygen or ozon These materials are detrimental to most organic insulations partic larly when such insulations are under physical tension, and th may cause premature failure of the insulation. This ionization indicated by the appearance of high-frequency oscillations on t charging current trace of the oscilloscope. In actual practice, t voltage at which ionization is extinguished rather than initiated determined. For long cable life, this extinction voltage should be least 110 per cent of the rated voltage to ground.

Wire and cable specifications generally require that these te be made on the completed product. High voltage and insulation r sistance tests are usually also made immediately after the insulatio has been applied and vulcanized. This is general insurance th cables passing the test will meet the requirements when complete

What's Radar?

by Jack Siebert, E. E. '57

Radar, a word coined by Captain S. M. Tucker of the U. S. Navy, is a discovery about which the general public knows little, but takes for granted. Almost everyone has seen moving pictures of a radar antenna, or perhaps actually seen one in operation, but relatively few have any idea of what takes place at the other end of the apparatus.

If one stands in the vicinity of a cliff and makes a noise of some sort, he will probably hear an echo of the noise. This echo is produced when the sound wave which he created bounces off the cliff and returns to his ears. The farther away the cliff is, the longer it will take the echo to return. Similarly, when one shines a flashlight on a wall, he readily sees a bright spot on the wall. The light waves have been reflected by the wall, and have been received by his eyes. Radar operates on this same principle, the difference lying in the fact that radio waves are used in place of sound or light waves. The word "radar" stands for radio detection and ranging. Designing the equipment to throw out these waves and to then receive them, required a terrific amount of research and technical know-how. The ratio of the tremendous amount of power generated to the minute quantity reflected can be emphasized in the following analogy:

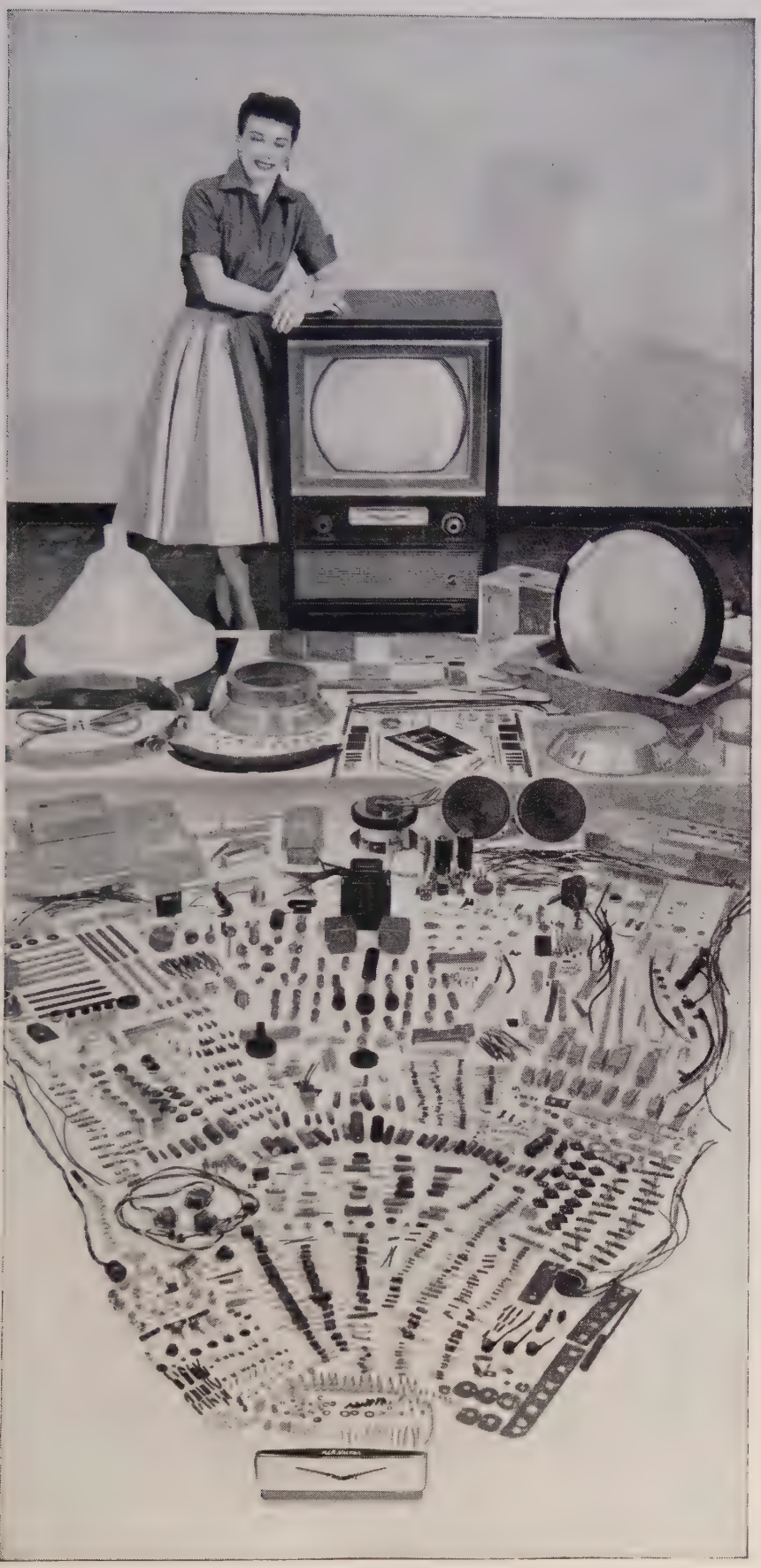
"If it were possible to scoop up all the sand on a typical seashore, throw it at a plane somewhere out of sight behind the clouds a hundred miles away, and have one grain bounce back to tell exactly where the plane was located, we should have a picture of the relative energies involved."[1]

This ratio makes it necessary to use an extremely powerful transmitter and a very sensitive receiver. The radio waves used in radar are in the microwave group. When the frequency of a a radio wave is increased, the wave length is decreased, and when the length reaches that of one meter or less it falls into the microwave category. When the radio waves become this short they are approaching the frequency of infrared heat and visible light. Consequently, they adopt many of the characteristics of these waves, one of which is to be able to be focused into beams much like searchlight. Such a beam of radio waves, which travel at 186,285 miles per second, can be aimed at an object, and information pertaining to the object can be gathered from the returning echo. The radar transmitter, however, does does not send forth a continuous beam of waves. It instead alternates with the receiver. A pulse is sent out, the transmitter shut off and the receiver turned on. When the echo has had sufficient time to return and be recognized by the receiver, it is turned off and the transmitter sends out another pulse. These pulses may be spaced at intervals of a microsecond, and the turning off and on is, of course, done electronically.

The transmitting division of a radar installation is made up of the following components: 1, a modulator, 2, a radio frequency oscillator, 3, an antenna. The modulator is the device which takes the power from the initial source, and after forming it into suitable voltages supplies it to the radio frequency oscillator which generates the microwaves. It is the modulator which turns the radio frequency oscillator on and off for its microsecond pulses. The radio frequency oscillator is a vacuum tube, or a system of tubes which is designed to deliver the desired burst of power at a determined frequency. In radar, hundreds of kilowatts of power may be needed to push the waves out into space. The procurement of a tube capable of producing the needed oscillations at such great power presented a difficult problem, but was accomplished by the development of a special tube called the cavity magnetron. After the high frequency oscillations have been produced it is up to the antenna to direct them out into space. Antenna design presents one of the major problems in radar The antenna must be highly efficient, easily directed in the desired directions, and produce the width of beam which is specified. Various types of beams may be incorporated. When a wide beam is used more complete coverage of the surrounding terrain can be accomplished than wit a narrow one; the difficulty lies, how ever, in that the location of an objec can not be precisely located. By usin a narrow beam the field of detection i made much smaller, and accurate de tails concerning the position of the ob ject can be recorded. Antennae can b made to revolve in a complete circle i necessary, or they can be adjusted t scan only a particular horizon. The can also be made to follow a patter which includes vertical movements Some radar antennae are parabolic i shape, as are reflectors for light rays.

When the pulses have been transmit ted and have been reflected from an ob ject, they are ready to be received an analyzed. The radar receiver may b thought of as two separate units, th detector and the indicator. The task o the detector is to receive the minut pulses of energy which are reflected t it, and to amplify and prepare then for the indicator. The receiver usuall uses the same antenna as does the trans mitter, and as already stated, operate during the period when the transmitte is shut off.

The radar indicator is the brains o the radar installation. It is the indicato which receives the information gathere by the detector and presents it in such a manner that the operator can put i to use. The method used is to show the effect of the returning echoes o the face of an oscilliscope. An oscillo scope is a closed, funnel-shaped glas tube. In the small end of this tube i a negatively charged electrode (cathode which directs a constant stream of elec trons towards the larger surface of th opposite end. This end of tube is coate with metallic salts that glow when the are struck by a bombarding electron By directing a magnetic field around th base of the tube, or by placing a posi tive electron (anode) in the path o the electrons, it is possible to contro the path of the electrons and consequent ly to produce a desired pattern on th face of the scope. By controlling th magnetic field with the incoming pulse from a radar antenna, the information which is received can be presented vis ually. There are several types of radar screen pictures. The basic and simples type is called a range indicator, whic really is not a picture at all. On th scope, a sweep line, called the time base extends across the surface horizontally As each pulse is transmitted a vertica column called a "pip" starts across th length of the line. The distance betwee these pips can be adjusted to represen any constant distance, and they ar therefore serving as range indicators. I an object comes into the path of th radar waves, it will reflect some of them back to the antenna, and after being re



This picture shows how RCA helps small manufacturers grow

Today the inter-dependence between manufacturer and supplier is stronger than ever in the history of American business. For in the challenging new age of electronics, hundreds upon hundreds of component parts are needed in the manufacture of new products.

For example, the superb new RCA Victor 21-inch color TV set shown here contains 2,070 parts. These are made by 600 different suppliers, most of whom are small businesses.

Indeed, more than three-quarters of all RCA suppliers are small business firms that receive nearly one-half of RCA's purchasing dollars. They, in turn, have their suppliers of raw materials. Thus through a long line of cooperative effort, employment is provided for countless people in many fields—and an entire economy benefits.

RCA salutes its full roster of 7,500 suppliers, located in 43 states, for their inventiveness and resourcefulness that contribute so much to the quality and performance of its products. With these firms at our side, RCA continues to march forward, creating new and better "Electronics for Living"—electronics that make life easier, safer, happier.

WHERE TO, MR. ENGINEER?

RCA offers careers in research, development, design, and manufacturing for engineers with Bachelor or advanced degrees in E.E., M.E. or Physics. For full information, write to: Mr. Robert Haklisch, Manager, College Relations, Radio Corporation of America, Camden 2, N. J.

RADIO CORPORATION OF AMERICA
ELECTRONICS FOR LIVING

ceived will appear as a second pip of less height than, and in between the range marks. The distance of this pip from the left end of the time base line will determine how far from the antenna the reflecting object is located. By the use of two scopes, termed A and B, one horizontal and the other vertical, both the range and the altitude of an aircraft can be discovered. The scopes are calibrated in whatever units are convenient for a particular installation. Another widely used type of indicator is the Plan Position Indicator (PPI). This type differs from the range indicator in that the base line swings out from the center of the tube as a radius. This beam of light is synchronized with the antenna and will scan the same arc that the antenna is adjusted to cover. The advantage of this type is that it gives the range as a radius and the relative azmuth in one reading. Also, as in the case of a shoreline, rivers, lakes, or mountainous areas, it will reproduce a visual outline of the object being viewed. This, of course, is not true with relatively small objects such as planes and ships.

A great scientific discovery such as radar would not be so great if it were not so useful. The part which radar played in World War II was definitely a leading role. In fact, radar has been heralded as the greatest scientific development of the war. The Navy, which pioneered the development of radar, put it to great use. For the first time ships were able to "see" through the dark of the night. Besides being an aid in navigation, radar enabled a ship to train her guns on an enemy vessel which she could not actually see. This happened many times as in the following incident:

"Late on the evening of November 4, 1942, among the Solomon Islands in the South Pacific, one of our new warships was out looking for the enemy. Aboard the American vessel, radar, like an invisible searchlight, probed the darkness and discovered the presence of an enemy vessel more than eight miles away. The big ship lifted its gun muzzles towards the stars. They flashed and thundered. The second salvo, despite both darkness and extreme range, landed squarely on the target, which disappeared from the radar screen."[2]

The worth of radar was definitely proved in the war. Captains no longer needed to guess about the location of the enemy.

So accurate is modern radar, that it can trace the flight of a shell, and in the case of an enemy shell, trace it back to its origin. Radar is extremely valuable for the detection of enemy aircraft. It has even been combined with an anti-aircraft gun so that it will automatically detect the plane and both aim and fire the gun. Radar is also of definite value to aircraft. In the last war the Allies were able to successfully bombard Germany at night, and at the same time through heavy fog and clouds by utilizing radar. Radar is also used to aid a plane in making a landing. Two methods, known as Ground Controlled Approach (GCA) and Instrument Landing System (ILS), are commonly used. In GCA the pilot is given directions by a man on the ground, while in ILS the pilot reads instruments in the plane and is responsible for landing the plane.

As helpful as radar is, it also has its faults. Microwaves, unlike longer radio waves, will not travel beyond the curvature of the earth, therefore the range of radar is limited, and an airplane, by hugging the earth, may often escape detection. Also, methods have developed to counteract radar detection. Due to the fact that radar waves will not penetrate water, it is impossible to detect a submerged submarine. Its merits, though, are so numerous that they overshadow its faults, and it can truly be called a miracle of modern science.

[1]Don Caverly in "The Primer of Electronics and Radiant Energy."

[2]From a broadcast of the Joint Board on Scientific Information Policy—May 31, 1943.

INDUSTRIES THAT MAKE AMERICA GREAT

RUBBER . . . BOUNCING HIGHER AND HIGHER

Rubber, natural and synthetic, is so elastic in its applications to daily living that millions of people ride on it, walk on it, sit on it, sleep on it—in fact, use it in more than 80,000 different products. 1,498,906 tons were consumed in 1953 alone. This industry's remarkable growth (U.S. consumption of 2,419,700 tons, or 27.7 pounds per person, is forecast for 1960) is largely due to management's wisdom in reinvesting profits in the tools of production and distribution to encourage company growth.

Anyone whose memory goes back 10 years or more can remember the heroic efforts of the rubber companies by which they averted a serious wartime rubber shortage which threatened both military transport, and family transportation. The phenomenal gains made by the rubber industry in the last decade have met civilian demands and have provided an emergency stockpile as well.

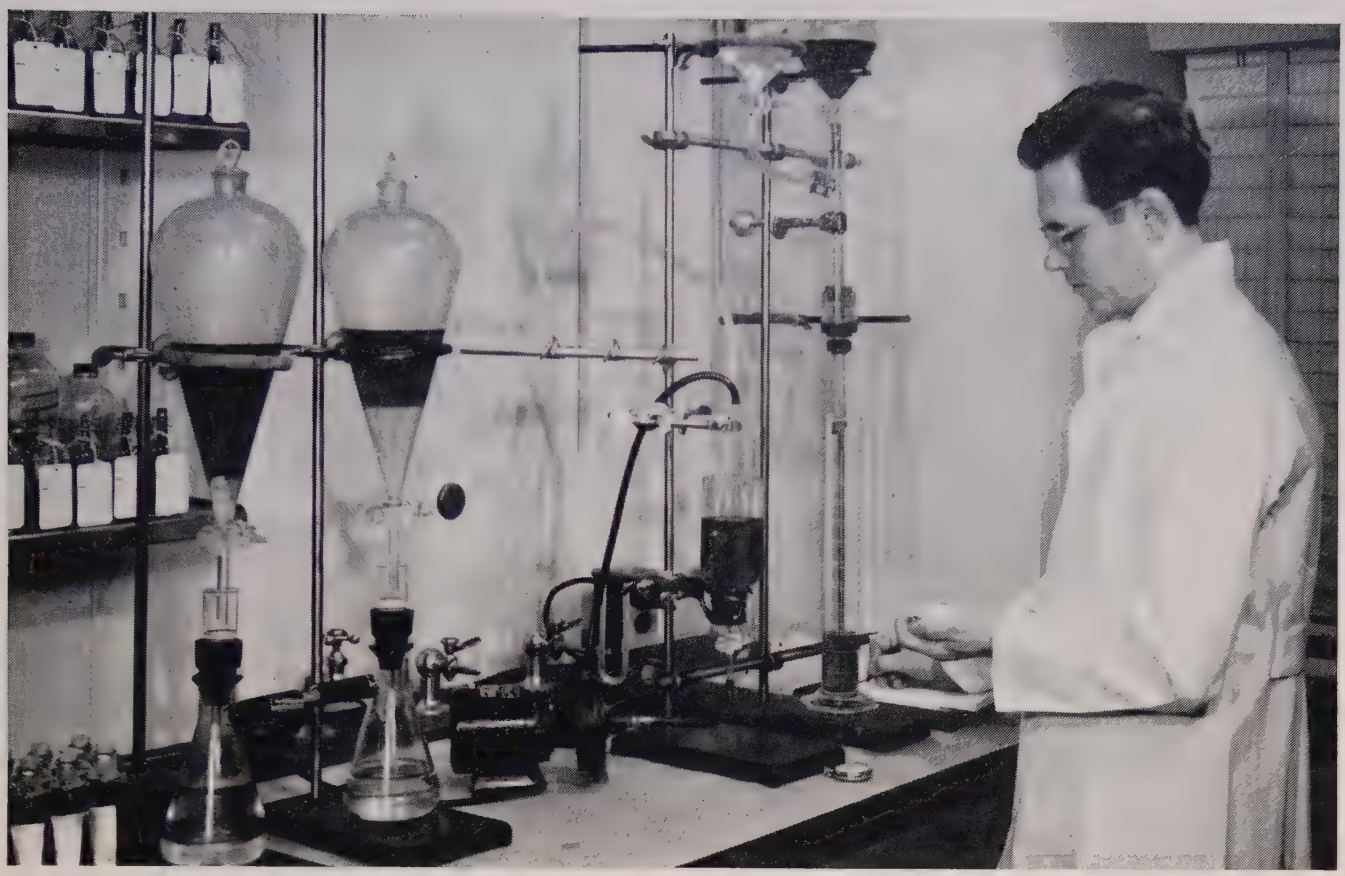
And in this history of rubber research, development and growth, steam has made—and is making—a basic contribution. Without steam and its teammate power, many of the accomplishments of rubber would have been more difficult, impracticable or even impossible to attain.

B&W, through its own vast program of research and development, coupled with boiler building experience dating back almost a century, has made major contributions of its own to the science of steam generation for processing, power and heat—and through them to the modern-day marvels of rubber.

BABCOCK & WILCOX

BOILER DIVISION

N-200



To help develop STA-CLEAN for STANDARD Furnace Oil, the testing apparatus shown here was constructed. Running an experiment on the improved oil is Dr. Jack A. Williams, a chemist at Standard Oil's Whiting laboratories.

HOW TO SOLVE A BURNING PROBLEM!

Scientists in Standard Oil laboratories work with the stimulating knowledge that practical and valuable results will be obtained from their discoveries. A recent achievement of Standard Oil scientists is now benefiting hundreds of thousands of STANDARD Furnace Oil users throughout the Midwest.

In 1952 our research people undertook the problem of finding a method to eliminate oil burner failure or inefficiency arising from clogged filters and burner nozzles.

After months of painstaking laboratory work and many more months of thorough field testing throughout an entire heating season, Standard Oil scientists perfected a new, efficient additive—STA-CLEAN. Blended into our furnace oil, the new additive acts as a detergent, sludge inhibitor and rust stopper—all in one. STA-CLEAN assures clean oil filters and nozzles—a dramatic contribution to efficient and economical heating.

The development of this remarkable new additive is further proof of the progress possible when scientists are given time and equipment to explore and develop thoroughly their ideas. Young scientists find such an atmosphere inspiring.

Standard Oil Company

910 South Michigan Avenue, Chicago 80, Illinois

STANDARD

Moving Sidewalks

—a reality

by John F. Aanes
M. E. '56

How many times did you leave the ballpark before the exciting game was over, just to beat the crowd and to get outside the stadium before everything got jammed up? This problem might be solved by a new and revolutionary development—the moving sidewalk.

Such a sidewalk was recently installed at Houston Coliseum in Houston, Texas. The design and installation was a joint engineering project of Link-Belt Company, B. F. Goodrich Company, and Otis Elevator Company.

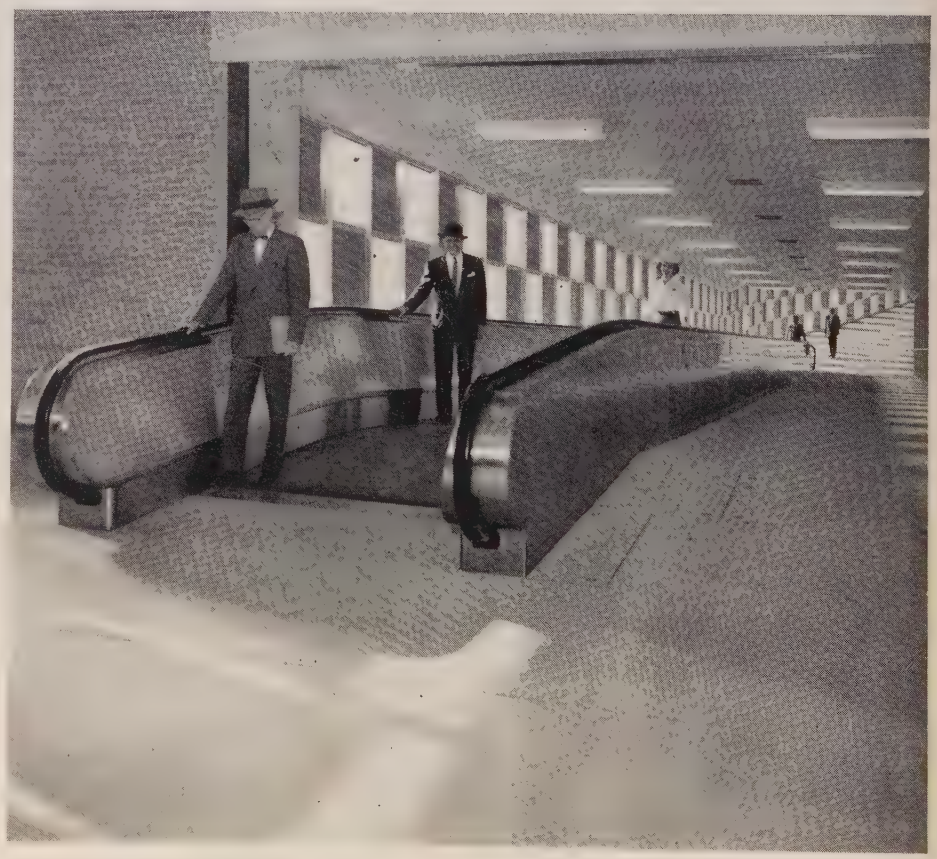
This "Link-Belt Walk" connects the Coliseum's exposition hall and auditorium with a parking lot which is on the other side of the Buffalo Bayou. It is the first moving sidewalk to be installed on a pedestrian bridge. The walk is 114 feet long, and the belt is 82 inches wide. It travels up a seven-degree (12 per cent) incline with a speed of 32 feet per minute, which is slightly faster than an ordinary escalator.

The whole run takes about 52 seconds, and the belt is capable of transporting 15,000 passengers in an hour. Passengers step on and off as if it were an escalator, and it gives them the option of riding without any effort or of adding their own walking speed for a quick trip.

In other words, the riders can either save time or effort. The run is reversible, so it can handle either in-going or out-going rush.

The Beltwalk is powered by a 25 h.p. motor through a double reduction helical gear and triple-width roller chain drive, which drives the pulley located at the upper end of the walk. The belt wraps tightly around the pulley and moves in the same direction. The belt itself is 230 feet long and seven-eighths inch thick and made of a specially compounded rubber and reinforced with

The twenty-foot pedestrian bridge between the Coliseum and the new parking lot.



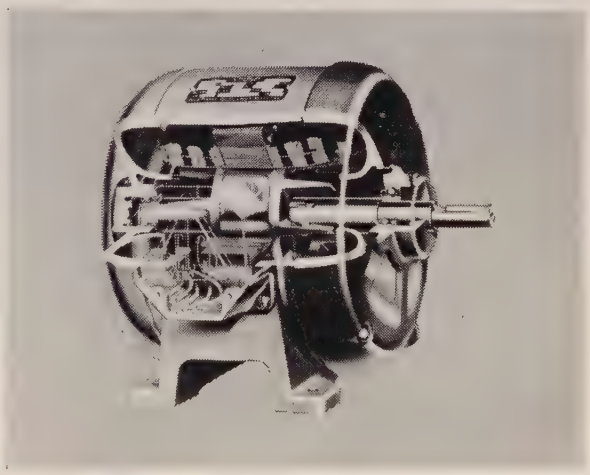
The "Link Belt Walk" at the Souston Coliseum in Houston, Texas—a 114-foot long moving sidewalk that can handle 15,000 people in an hour.

NIKOLA TESLA, THE MAN WHO HARNESSED NIAGARA

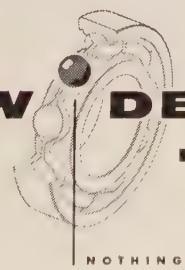
Water, water, everywhere — and no power. That was Niagara Falls when Nikola Tesla began work on its power system in 1888. Now Niagara is one of the world's largest electric power plants.

But to make the most of this power, many problems in electric motor design had to be overcome. New Departure ball bearings have helped solve many of them. For example, motors with New Departure self-sealed ball bearings may be mounted in difficult-to-reach locations because the bearings will operate for years without attention for relubrication or adjustments of any kind.

Highly important also are the facts that these ball bearings resist loads from *all* directions and, being grease-lubricated, permit motors to be applied in any position from horizontal to vertical without loss of efficiency or trouble from lubricant leakage. Whatever the loads, New Departure ball bearings maintain accurate rotor-to-stator relationship — are cool-running at all motor speeds.



New Departure ball bearings assure positive rotor support under all loads in this motor. Bearing seals, pioneered by New Departure, keep lubricant out of the motor. Shields on the reservoir side keep foreign matter out of the bearings.



NEW DEPARTURE
BALL BEARINGS

NOTHING ROLLS LIKE A BALL

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

ENGINEERING WRITING

Here is an ideal way for the engineer or physicist with some aptitude for writing to enter the field of advanced electronics. In this relatively new and expanding area you can make immediate and effective use of your academic training while acquiring additional experience.

Hughes Research and Development Laboratories are engaged in a continuing program for design and manufacture of integrated radar and fire control systems in military all-weather interceptor aircraft. Engineers who produce the maintenance and operational handbooks for this equipment work directly with engineers and scientists engaged in development of radar fire control systems, electronic computers, and other advanced electronic systems and devices.

Your effort in the field of engineering writing through these publications transmits information to other engineers and technical personnel on operation, maintenance and modification of Hughes equipment in the field.

You will receive additional training in the Laboratories at full pay to become familiar with Hughes equipment. Seminars are conducted by publications specialists to orient new writers. After-hours graduate courses under Company sponsorship are available at nearby universities.

HUGHES
RESEARCH AND DEVELOPMENT LABORATORIES

SCIENTIFIC AND ENGINEERING STAFF

Culver City, Los Angeles County, California

Photograph above: Engineer-writer John Burnett (left) works with engineers John H. Haughawout (right) and Donald King to compile handbook information.

seven plies of fabric. The two ends are vulcanized together to make the walk and endless loop.

The sidewalk is enclosed by three feet high balustrades with moving handrails. The handrails are extended beyond the moving belt at both entry and exit ends and their speed is synchronized with the speed of the belt.

All parts of the "Link-Belt-Walk" have been designed for maximum safety. The steel idler rolls under the belt are spaced so close that they give a perfectly smooth and effortless ride. The operation is almost noiseless, and all the mechanical parts are enclosed. Still they are accessible for inspection and maintenance, and the belt is easily cleaned.

The sidewalk in Houston Coliseum is the first Link-Belt installation for the public transportation of people. But other companies have made similar installations. A good example is Stephens-Adamson Mfg. Co.'s 227 feet long "Speedwalk" through the Hudson and Manhattan Railroad Company's Erie tube station at Jersey City.

Extensive studies are now being conducted by engineers, architects and traffic experts to determine the future use of moving sidewalks to eliminate the bottlenecks in the pedestrian traffic lanes, convention halls, airports, sports stadia, shopping centers, subways, and so on.

Look for moving sidewalks tomorrow. They are the solution to today's pedestrian traffic problems.

A hot-spell story that we like is about the girl who went swimming in the raw in a secluded millpond. Along came a little boy who began to amuse himself by tying knots in her clothes. She floundered around, found an old washtub, held it up in front of herself, and marched toward the little boy, saying "You little brat, do you know what I'm thinking?"

"Sure," said the little brat, "you think that tub has a bottom in it."

* * *

Some girls are like a zippered nightie: pull anything and it's all off.

* * *

Flossy: "I was out with an inebriated driver last night and he headed right for a telephone pole."

Tessy: "The dog!"

* * *

"What was that explosion on Si's farm?"

"He fed a chick some 'Lay or Bust' feed, and it turned out to be a rooster."

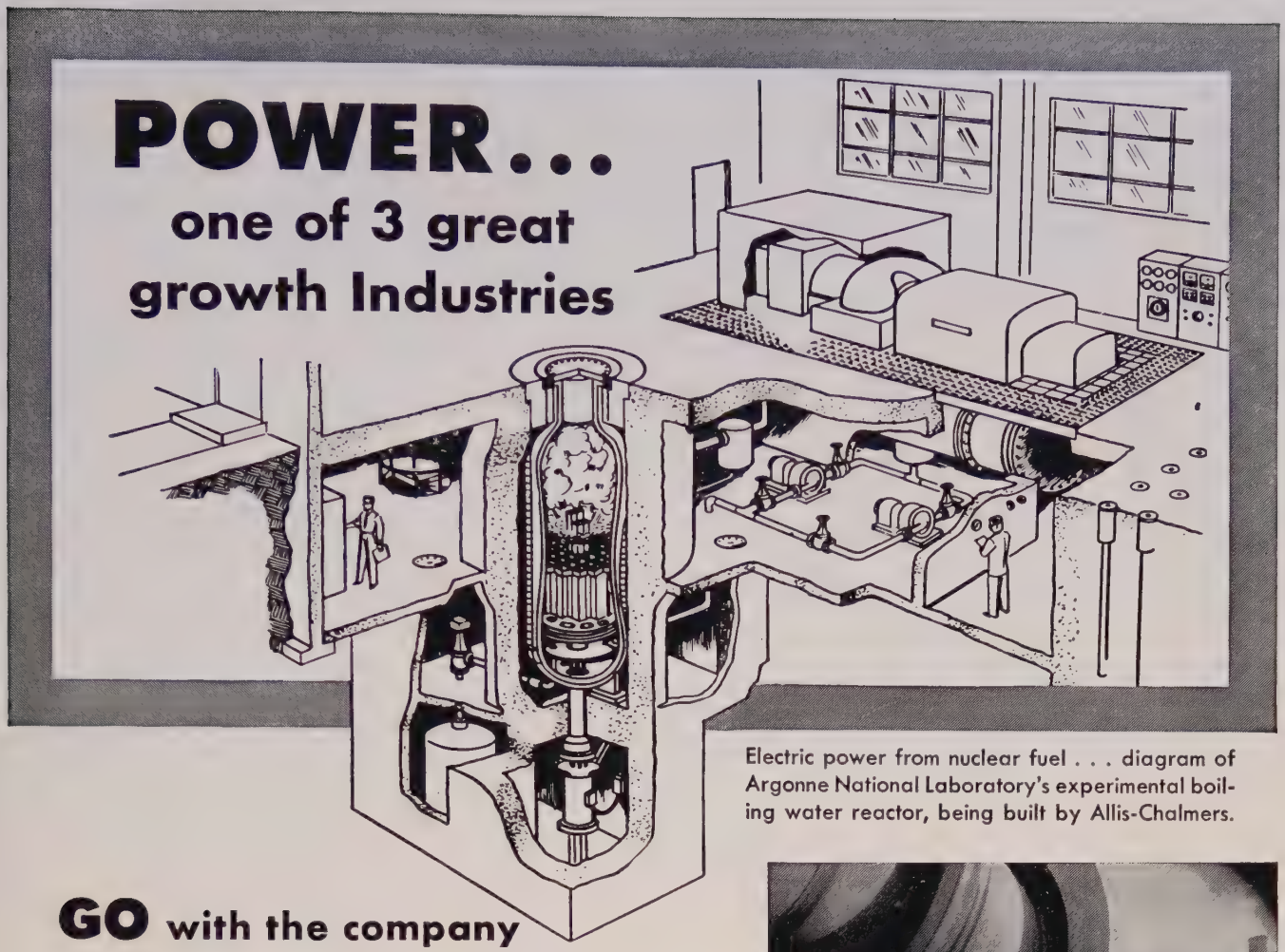
* * *

Professor—In what battle did General Wolfe, hearing of victory, cry, "I die happy?"

Student—His last battle.

POWER...

one of 3 great growth Industries



Electric power from nuclear fuel . . . diagram of Argonne National Laboratory's experimental boiling water reactor, being built by Allis-Chalmers.

GO with the company that's strong in all three!

Hitch your future in engineering to the growth of the U. S. A.—and to a company that supplies the basic needs of growth!

This nation is growing at the rate of 50,000 people every *week!* To supply the needs of these people:

Electric power generation will double by 1965.

A multi-billion dollar program of new highway construction is planned within the next ten years.

Manufacturing output will have to increase by $3.5 billion by this time next year.

And Allis-Chalmers builds major equipment for all of these growth industries! Some examples are pictured here.

Here's what Allis-Chalmers offers to Young Engineers:

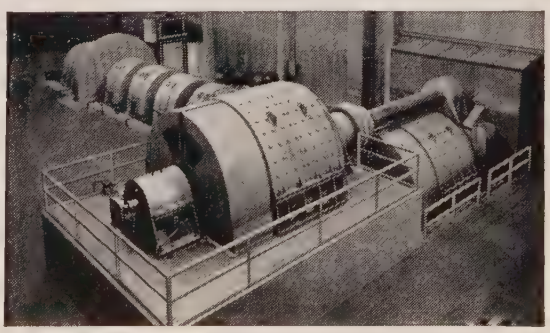
A graduate training course that has been a model for industry since 1904. You have access to many fields of engineering: electric power, hydraulics, atomic energy, ore processing.

There are many *kinds* of work to try: design engineering, application, research, manufacturing, sales. Over 90 training stations are available, with expert guidance when you want it. Your future is as big as your ability can make it.

Or, if you have decided your field of interest and are well qualified, opportunities exist for direct assignments on our engineering staff.

In any case—learn more about Allis-Chalmers. Ask the A-C manager in your territory, or write direct to Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.

CONSTRUCTION demands the vast tonnages of cement produced with Allis-Chalmers rotary kilns and other processing machinery.



MANUFACTURING depends upon the reliable power of electric motors—like these 5000 hp Allis-Chalmers giants powering a rolling mill.

ALLIS-CHALMERS

A-4683

by Larry Kiefling, M. E. '56

PARKER BADGER

About 2 years ago, in January 1953, a 36 year old man named Parker H. Badger received a diploma from Milwaukee Vocational High School. He is graduating this spring with University

PARKER BADGER

Honors and a degree in mechanical engineering.

Before coming to the U. of I., he had seen a lot of the U. S. and the world. He was born in Boston, and raised in Washington and Philadelphia. He was in the Corps of Engineers during WWII in both the European and Pacific theaters. He had studied air conditioning at Milwaukee School of Engineering for a year and refrigeration in Philadelphia for a semester. He was a machinery salesman for 5 years, and a credit manager for 7 years. He also operated an office supply business.

When asked what made him decide to come to college, he indicated that his lovely wife, Barbara, had no little influence on his decision. At the present time, she is working as a secretary in a LAS dean's office.

Parker is a member of ASME and several honorary fraternities. During his last semester, he was president of ΠΤΣ, mechanical engineering honorary. He also belongs to ΤΒΠ and ΣΤ, engineering honoraries; ΠΜΕ, math honorary; and øKø, all university honorary.

JIM PIECHOCKI

Techno-Cutie

Our TECHNO-CUTIE for this month is KAY BOWMAN. Kay is a sophomore in FAA, with a major in art. She has been selected to a host of queen positions including horse show queen, Illio finalist, and dream girl of Pi Kappa Alpha. Kay has been active in Star and Scroll and she has reached the finals this year for cheerleader. In her spare time, Kay enjoys golf, swimming, painting, and horseback riding. Just for the record is nineteen, 5'7", weighs 130 lbs., and she measures 36 - 24½ - 36, either way. Before you run to the nearest telephone, fellows, this blue-eyed blond has been spoken for.

JIM PIECHOCKI

Under the title of one of the main articles in each of this year's Technographs is the credit "by Jim Piechocki, Aeronautical Engineering, 1956." The articles, which deal with such various topics as the sun, the Pogo plane, a WWI ace, Omar Khayyam, an oil refinery, and rocket research, show the wide field of interest of the author.

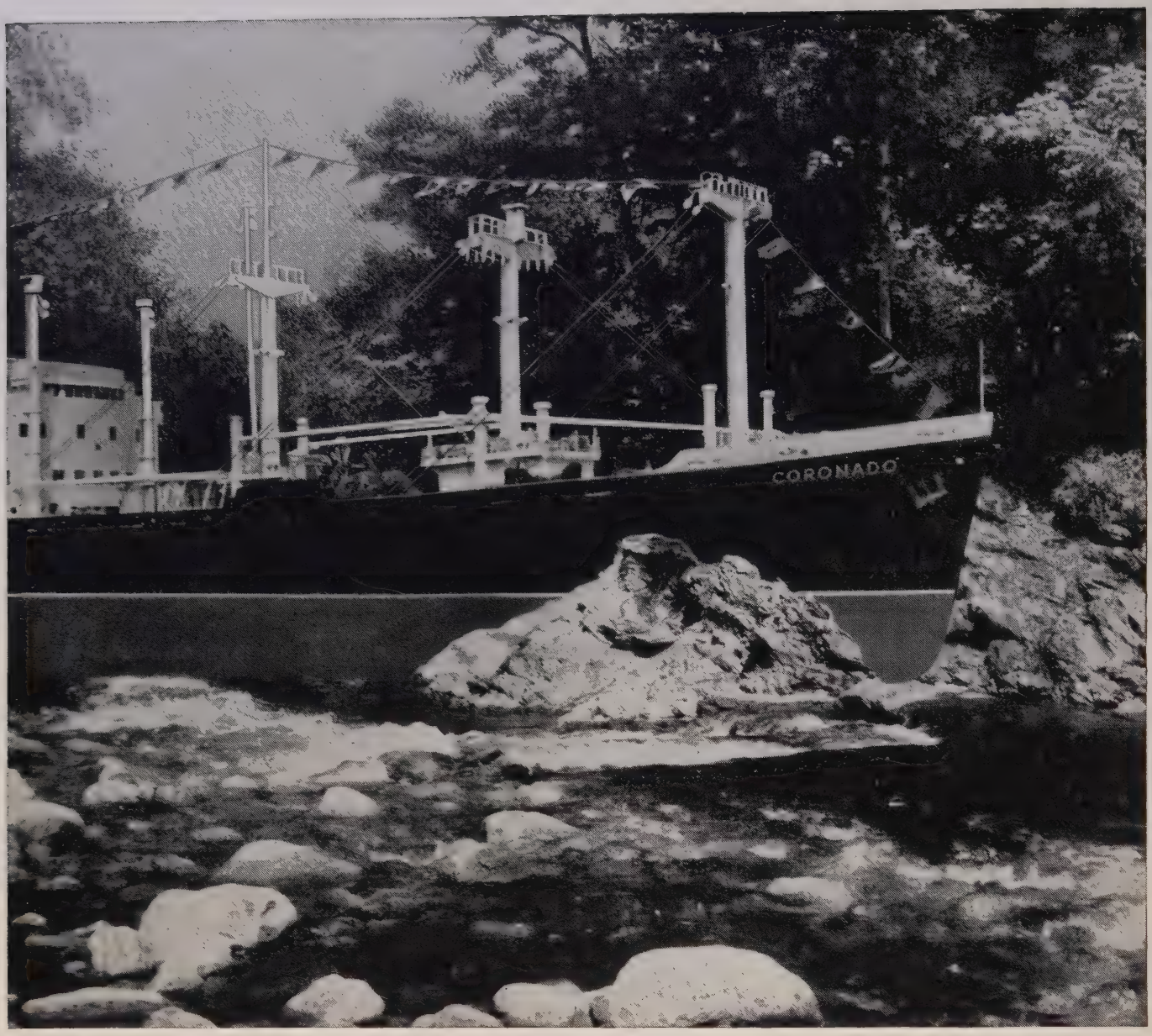
A native of Chicago, Jim transferred to the Urbana campus from Navy Pier. While at the Pier, he engaged in many diversified activities. He was chairman of the Institute of Aeronautical Sciences (Student Branch), chairman of the Engineering Counsel for a semester, and a track manager. He also wrote several Technograph articles while at the Pier.

Since coming to the Urbana campus, he has continued his many activities. He is vice chairman of I. A. S. and has been elected chairman for next year. He was in charge of the exhibits of the Aeronautical Engineering department at the 1955 Engineering Open House. Jim is also the editor of the Newman Club paper, the "Cardinal."

When he can find time away from writing and aerodynamics, Jim likes to play baseball, dance, or listen to classical music.

Old Lady—Are you a little boy or a little girl?

Child—Sure, what the hell else could I be?



You can't launch an ocean liner in a mountain stream

Initiative alone is not the answer to a man's career. A man can't travel far in narrow, limited confines. Neither can he expand in an unprogressive, stagnant organization. A man needs opportunity to put his ideas into action. He needs to be able to move ahead without waiting for vacancies to occur from death or retirement.

Columbia-Southern is one of the fastest growing companies in the fast-growing chemical industry. It is progressive, alert, and on the move.

Opportunities exist with Columbia-Southern in engineering, research and development, sales, plant design, mining, construction, maintenance, production, accounting, transportation and related fields.

Columbia-Southern encourages its employees to grow professionally and the management believes in placing men in positions of greater responsibilitity as soon as they are ready for it.

Columbia-Southern is going places and it needs good men. If you would like to be a part of this organization, write today for further information to Department P at our Pittsburgh address or any of the plants.

COLUMBIA-SOUTHERN CHEMICAL CORPORATION

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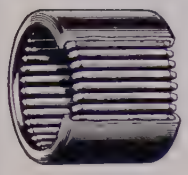
IN CANADA: Standard Chemical Limited and its Commercial Chemicals Division

The Torrington Needle Bearing ...designed for easy, effective lubrication



One major advantage inherent in Needle Bearing design is the ease with which the bearing can be lubricated.

The full complement of small diameter rollers continuously carries a thin film of lubricant to all contact surfaces. The turned-in lips of the outer shell retain the lubricant and effectively seal out foreign matter.

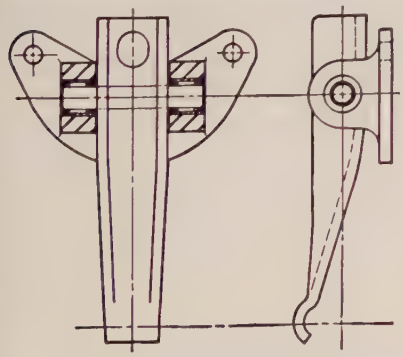
Methods of Lubrication

When Needle Bearings are shipped, they are normally protected with a high-grade slushing compound which has lubricating value at ordinary temperatures. This compound is left in the bearings in most instances. Needle Bearings in many applications run for long periods of time without further attention to original lubrication.

There are several methods of providing additional lubricant to Needle Bearings, as illustrated and described below.

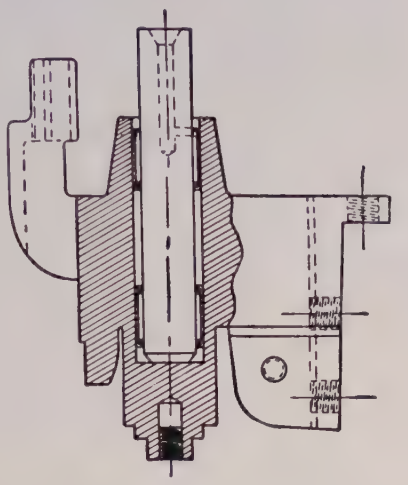
PERMANENT LUBRICATION

For low speed and light load applications, as in the fingers of the automobile clutch illustrated, the Needle Bearings are packed with grease before assembly. No additional lubrication is needed.



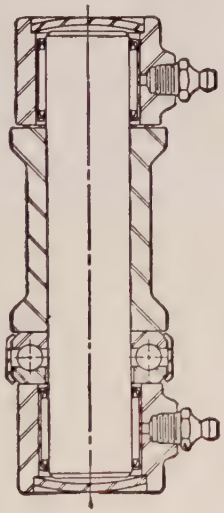
THROUGH THE SHAFT

If it is necessary to lubricate through the shaft, a hole is drilled along the shaft axis, with a cross hole leading under the lips of the Needle Bearing. This hole is located under the lip of the bearing rather than in the roller contact area. Textile machine spindle swing bracket below illustrates this method.



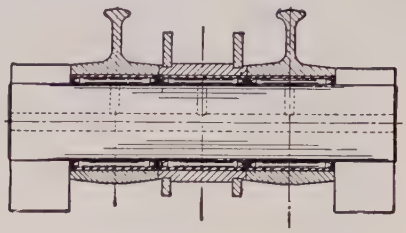
THROUGH THE HOUSING

When lubricant is to be delivered through the housing, an oil hole is furnished in the middle of the outer shell. In automobile king pin below, Needle Bearings are lubricated with Alemite fittings through the oil hole. This oil hole in the outer shell should be outside the load area.



CIRCULATING OIL SYSTEM

For high speeds and heavy loads, a circulating oil system is preferred as it aids in carrying away heat as well as in providing a continuous supply of lubricant to the bearing contact surfaces. A typical example of this method is shown in this Needle Bearing application in the valve rocker arm of a large diesel engine shown below.



Selecting A Lubricant

While oil is the best lubricant, it is difficult in many cases to retain it in the bearing housing. In general, a soda base grease is used in the absence of moisture, and a lime base grease when moisture is present. It is usually advisable to consult a grease manufacturer regarding a particular application.

These features make the Torrington Needle Bearing Unique

- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts

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District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

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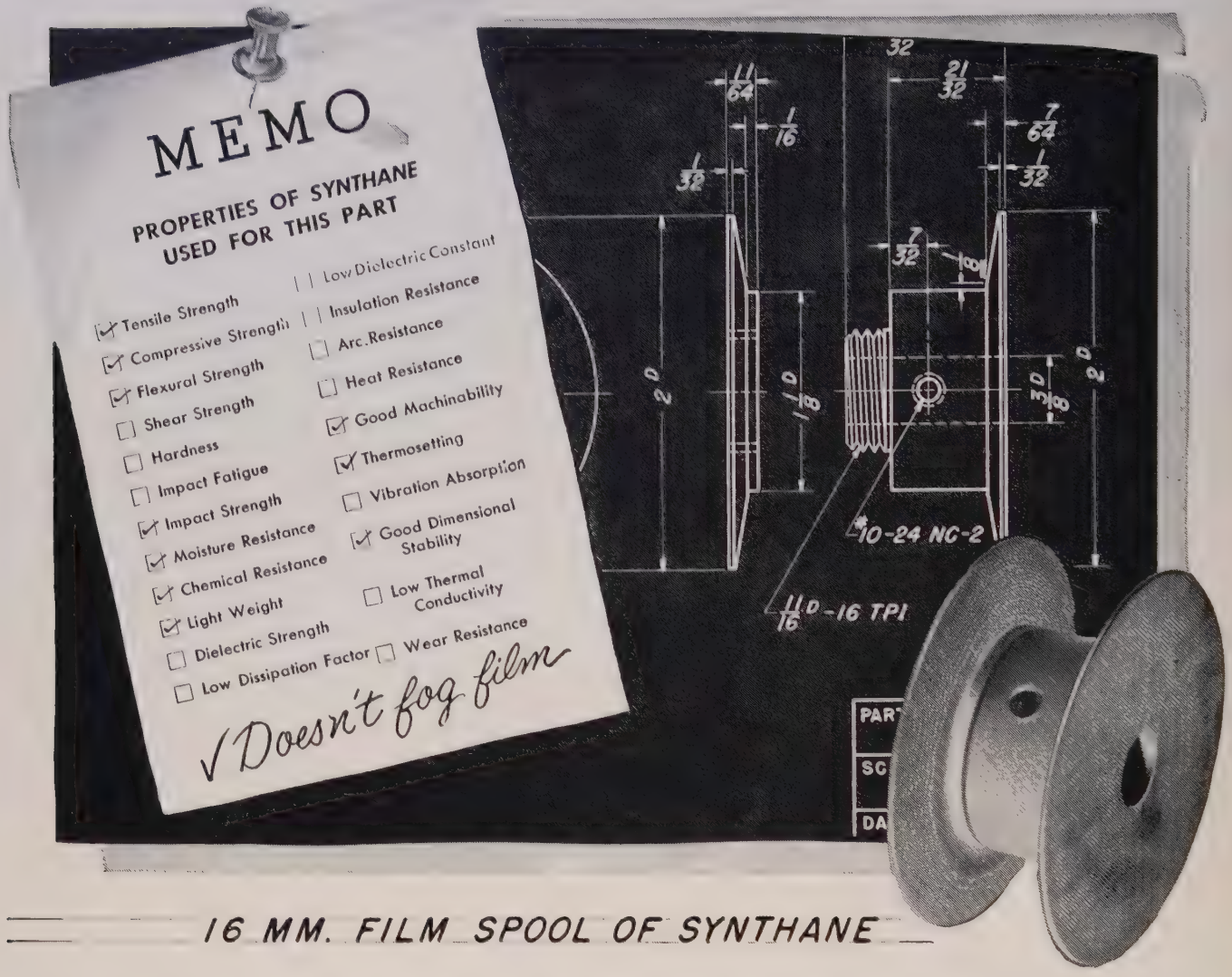
YOU FURNISH THE PRINT, WE'LL FURNISH THE PART



16 MM. FILM SPOOL OF SYNTHANE LAMINATED PLASTIC RESISTS PHOTOGRAPHIC CHEMICALS, HOLDS SHAPE, DOESN'T FOG FILM

The film spool we're talking about is one used in the processing of movie film. The material for this spool has to be light in weight, strong and easily machined. Since it is always in contact with film and photo solutions, it must also be chemically-resistant and—most important—not fog the film by chemical contamination.

This isn't an easy assignment for any material, but *Synthane* fills the bill.

Whenever you want parts requiring many properties, consider how *Synthane's* combined benefits may help you improve your product.

Synthane produces finished parts from many different grades of *Synthane* laminated sheets, rods, tubes and molded-laminated and molded-macerated parts. Service and quality characterize *Synthane* fabrication.

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SKIMMING INDUSTRIAL HEADLINES

by Larry Kiefling, M. E. '56

xperimental Battery Converts adiation to Electricity

A tiny semiconductor device that conerts either light or atomic radiation irectly to usable electrical energy was escribed here today by scientists.

The device, a silicon junction simiar to those used in transistors and in he RCA Atomic Battery, has been emloyed in experimental solar and atomic atteries at the David Sarnoff Research Center. Using light and radioactive maerial interchangeably as sources of radiation, these batteries have powered a pecially designed low-power transistorzed radio receiver.

Discussing continuing RCA research n methods of converting radiation directly to electric power, the scientists ointed out that batteries capable of uch conversion promise to find importnt application in the near future as ources of electrisity for low-power elecronic equipment, especially in the field f transistorized devices.

The unit in which radiation is conerted to electricity is a wafer of silicon nto which an impurity is alloyed to orm a junction. When the wafer is xposed to bombardment either by beta articles from a radioactive source or by hotons of light, electrons are released ithin the silicon. These electrons, flowng across the junction, produce a voltage that can be applied to a circuit and cause a current to flow.

The unit employed in the experiments is a junction about ¼ inch in diameter and 1/100 inch thick. To produce enough current to operate a low-power radio, the scientists said, several such units have been connected in series and operated with both atomic and light radiation sources.

A low-power radio was designed for tests with the batteries. It was described in the report as a diode detector followed by three transistor audio amplifiers feeding into an earphone. Because of the low available power from the batteries, the radio used only 10 millionths of a watt in operation, but successfully picked up commercial broadcasts at short range.

The radioactive source employed in the experiments is strontium-90, an atomic fission by-product. When a radioactive source is used, the report said, the junctions are arranged around the material so as to intercept as much as possible of the radiation. In a light battery, it added, the same junctions are arranged to expose as much surface as possible to the light source. An experimental light battery having twelve silicon junctions mounted in a Lucite case has operated the low-power radio in average room light, the scientists said.

The report indicated that some problems remain to be overcome in order to achieve commercially practical atomic and light batteries. One such problem in atomic batteries, the scientists said, has been damage to the crystal wafer by beta particle bombardment. The report stated, however, that such damage ordinarily decreases as the energy of radiation decreases, and that a threshold energy is now believed to exist below which damage will not occur.

Summarizing progress in the development of atomic and light batteries, the scientists stated that prospects for application lie in areas where low power is required, since the potential power range of devices now being studied is less than that of the common dry cell.

Case-less Emergency Lantern

An ingenious utility lantern, the first for poular use ever to utilize a battery which itself is the battery case and with up to four times the life of the ordinary lantern battery, has been designed by the Burgess Battery Company.

The "Radar-Lite" was developed to fill a long-standing need for a lantern with tremendous staying power, yet simple and lightweight enough for women to use as a car or home emergency light, and professionally dependable and powerful enough to be suited for use as industrial standby lighting, auxiliary transportation and marine signal lamps, and for use as reserve disaster and A-bomb shelter emergency equipment.

Measuring only 4x5 inches, the unified battery-and-case is leakproof, and entirely sealed in steel with a reinforced steel ribbed top. It attaches to a removable twin light head with two simple insulated screw caps. To connect the battery and make the circuit, there are no wires to hook up or battery spring contacts to make. The electrical circuit is completed by the metal frame of the light head itself.

An adjustable sealed beam spotlight that can be tilted up or down 135 degrees is the primary light source. A movable red warning light, flashing more than 50 times a minute, which can be operated vertically or horizontically, is mounted to the rear of the spotlight. Both lights are operated with independent silver contact switches.

The power pack consists of two 6-volt lantern batteries wired in parallel to yield the most powerful unit of its type ever developed. Laboratory tests indicate its useful life at 2½ to 4 times that of the conventional single 6-volt lantern battery.

Besides its functions as a universal safety light for motorists and as an all-purpose home lamp for use by women, the new lantern was designed to serve as emergency and standby lighting in industry, hospitals, schools, and other institutions; for portable farm illumina-

Systems Development and The Ramo-Wooldridge Corporation

The Ramo-Wooldridge Corporation (except for the specialized activities of our subsidiary, Pacific Semiconductors, Incorporated) is engaged primarily in developing—and will soon start to manufacture—systems rather than components. For military customers our weapons systems responsibilities are in the fields of guided missiles, fire control, communications, and computers. Our non-military systems activities are in the general area of automation and data-processing.

Emphasis on systems development has consequences that profoundly affect all aspects of an organization. First, it demands an unusual variety of scientific and engineering talent. A single systems development project often requires concurrent solutions of challenging problems in the fields of electronics, aerodynamics, propulsion, random phenomena, structures, and analytic mechanics. In addition, the purely technical aspects of a systems problem are often associated with equally important nontechnical problems of operational, tactical, or human relations character.

Therefore, competent systems development requires that a company contain an unusually large proportion of mature, experienced scientists and engineers who have a wide range of technical understanding and an unusual breadth of judgment. Further, all aspects of company operations must be designed so as to maximize the effectiveness of these key men, not only in the conduct of development work but in the choice of projects as well.

At Ramo-Wooldridge we are engaged in building such a company. Today our staff of professional scientists and engineers comprises 40% of the entire organization. Of these men, 40% possess Ph.D. degrees and another 30% possess M.S. degrees. The average experience of this group, past the B.S. degree, is more than eleven years.

We believe the continuing rapid growth of our professional staff is due, in part, to the desire of scientists and engineers to associate with a large group of their contemporaries possessing a wide variety of specialties and backgrounds. It is also an indication that such professional men feel that the Ramo-Wooldridge approach to systems development is an appropriate one.

We plan to continue to maintain the environmental and organizational conditions that scientists and engineers find conducive to effective systems development. It is on these factors that we base our expectation of considerable further company growth.

POSITIONS ARE AVAILABLE FOR SCIENTISTS AND ENGINEERS IN THESE FIELDS OF CURRENT ACTIVITY:

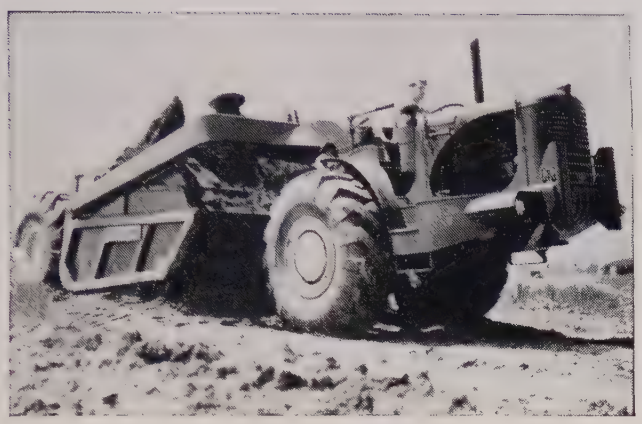
Guided Missile Research and Development
Digital Computer Research and Development
Business Data Systems Development
Radar and Control Systems Development
Communication Systems Development

The Ramo-Wooldridge Corporation

8820 BELLANCA AVENUE; LOS ANGELES 45, CALIFORNIA

Another page for **YOUR BEARING NOTEBOOK**

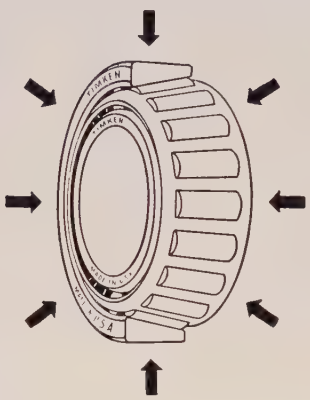
How to increase gear life in a scraper



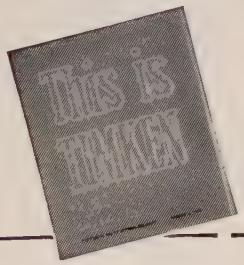
When this 13 cubic yard scraper, fully loaded, travels at 25 MPH over rough terrain, the gears in the differential, engine shaft and pinion get a workout. Realizing this, the engineers specified Timken® bearings for these vital applications. The tapered construction of Timken bearings lets them take radial and thrust loads in any combination. Gears are held rigidly in place. Perfect tooth-mesh is maintained. Gears last longer.

How TIMKEN® bearings hold gear shafts rigid

The line contact between rollers and races of Timken bearings gives shafts rigid support over a wide area. Shaft deflection is minimized. And the tapered design of Timken bearings permits them to be set up with the most desirable amount of end play or preload that gives the best performance.

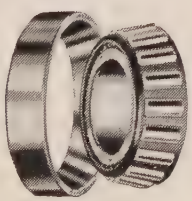


Want to learn more about bearings or job opportunities?



Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, O.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭
BEARING TAKES RADIAL ⊕ AND THRUST —◎— LOADS OR ANY COMBINATION ✳

The Radar-Lite, used for marine signal lamps, has tremendous staying power yet light weight.

tion; for general outdoor, construction, and field use; and for auxiliary highway, rail, marine, and aircraft lighting. It was also conceived as a practical solution to the present need for dependable reserve lighting for homes and offices and as basic civil defense equipment.

Output Increased U.S.S.R.

The Soviet Union increased its industrial output more than eightfold in the quarter-century between 1928 and 1953, and have doubled industrial manhour productivity since 1928.

In spite of these advances, the volume of Soviet manufacturing and mining in 1954 was only about 35 per cent of that of the United States.

These figures were revealed by a Russian-born expert at the diamond jubilee spring meeting of the American Society of Mechanical Engineers.

The speaker was Demitri Shimkin, social science analyst with the U. S. Department of Commerce, Bureau of the Census. Mr. Shimkin was born in Omsk, Siberia. He was a colonel during World War II, on the general staff, G-2 (intelligence), European theater. He was formerly a lecturer on strategic logistics of the U.S.S.R., at the U. S. Naval War College and the National War College.

Mr. Shimkin said that two fundamental considerations dominate the selection, training and use of physical scientists and engineers in the Soviet Union. The first is the vital role of these specialists in building up Soviet military-economic strength. The other is Communist fear of scientists and engineers as potential subversives.

Summing up, Mr. Shimkin said that "the selection, training and use of physical scientists and engineers in the Soviet Union reveals paradoxical strengths and weaknesses. The application of science on a vast scale is essential to the realization of Soviet ambitions, yet the Communist party dare not trust the scientist and the engineer. The Soviet Union fears the West, yet depends upon its technology."

Given these circumstances, he said, the following conclusions may be advanced:

"1. At the present time, the actual effectiveness of the Soviet Union is scientific innovation and application is far lower than might be indicated by the large number of its physical scientists and engineers, and by the immense Soviet effort, in training and research.

"2. In part, this gap lies in the failure to develop and apply increasingly good basic research. Thus, Soviet science warrants far closer study by the West than Soviet technology indicates.

"3. Beyond this, the Soviets are creating a potential which, given appropriate social changes, might generate a technological revolution.

"4. At the present time, the Soviet utilization of Western technology is limited by Western controls on information flow and exports. Moves toward the modification of these controls should be guided by careful assessment of Soviet technological strengths and weaknesses.

"5. Finally, scientific and technical publications, including trade journals, are a channel of communication behind the Iron Curtain which the Soviet Union simply must keep open. This fact needs wide exploitation both as a means of ensuring a reverse flow of data from the Soviet Union and as a medium for the diffusion of a new hope for a world of peace."

Mr. Shimkin's talk was presented as part of a panel presentation on "The Engineer and the Prospects for Peace."

The ASME meeting here was part of the society's celebration of its 75th anniversary year, and was devoted to the theme, "The Engineer and the World of Government."

Sodium Cooled Reactor

Progress is being made in the solution of problems in the use of sodium as the coolant in nuculear reactors. D. R. Miller and W. E. Cooper, Knolls Atomic Power Laboratory of the General Electric Company, covered some of the design problems of a reactor in which the temperature of the sodium would vary between 600 and 850 degrees F. normally. These temperatures would allow a satisfactory thermal efficiency in the power plant and leave a margin for somewhat higher local temperatures without undue loss of structural strength and ductility.

It was explained that the metal sodium has advantages as a coolant primarily because of its high heat transfer coefficient, several times that of water, and its high boiling point, 1621 deg. F. at atmospheric pressure. It has the additional advantage that its high electrical conductivity, about 20 per cent that of copper, allows efficient pumping with electromagnetic pumps, thus permitting elimination of shaft seals or canned rotor motors. Because of the high heat transfer coefficients, the temperature rise from the main coolant stream to the fuel element surface is small, even with high heat flux densities.

One of the principal difficulties in the reactor design arises from the fact that major loadings are thermally induced, which is rare in other power systems. Sodium's high heat transfer coefficients increase thermal transient stresses in structures in contact with the coolant, since the metal surfaces closely follow the transient temperatures of the sodium. This makes fast temperature transients much more significant with sodium than with water, vapors or gases.

Another disadvantage of sodium is that electrical heaters must be provided to keep the coolant fluid during filling and shutdown. Also sodium becomes highly radioactive and must be contained within a biological shield. Furthermore, to guard against the sodium-water reaction hazard, the system would use multiple barriers between sodium and water, and the intervening space would be monitored for leak detection.

In spite of these limitations, extensive experience gained in other types of installations shows that systems utilizing sodium can be made reliable in operation, and with appropriate safety precautions the hazards are no greater than those in many other common industrial systems. The general plan is to assure adequate structural design strength through establishment of conservative stress limits, the recognition of all significant problems, close attention to design details, extensive theoretical and experimental stress analysis, close cooperation among designers, analysts, metallurgists and manufacturing personnel and the resolution of borderline cases individually after consideration of all factors, including schedules and consequences of mechanical failures.

The authors stated that they are not satisfied with present design bases for stress limitation, but are striving for improvement which must be accompanied by increased knowledge in the field of metallurgy and stress analysis. The fatigue behavior metals subjected to strain cycling is being studied further under severe conditions, for example. Further fundamental investigation, theoretical and experimental, of many additional problems is necessary. The aim of improved design bases is to provide more definite safety factors and a minimum of restraint on design because of ignorance of stresses and their effect on structures.

CATERPILLAR MACHINES POWER THE WORLD'S GREAT ENGINEERING JOBS

The young engineer who works for Caterpillar Tractor Co. has a part in great achievements. All over the world new construction is going forward at an unprecedented pace. And the powerful diesel engines and earthmoving machines built by Caterpillar are leading the way.

This is a dynamic industry—an industry of growth. In the next few years engineering strides made by Caterpillar will surpass all that have gone before. To share in this advance the company needs young men of vision, trained as Mechanical, Metallurgical, Agricultural, Electrical, Civil Engineers and others. They will do challenging work in research and development, design, manufacturing, sales and many other fields. They will have the best in laboratory facilities and interesting assignments in Caterpillar plants as well as in the field.

Such men can expect permanency and promotion. Starting pay is good. In addition, executive positions at Caterpillar are filled from within the organization.

It's time now to start thinking about a Caterpillar job. Representatives of the company will be on campus for interviews. Consult your placement office. Meanwhile, if you would like further information, write to W. C. van Dyck, Employee Relations General Office, Caterpillar Tractor Co., Box IL-4, Peoria, Illinois.

CATERPILLAR

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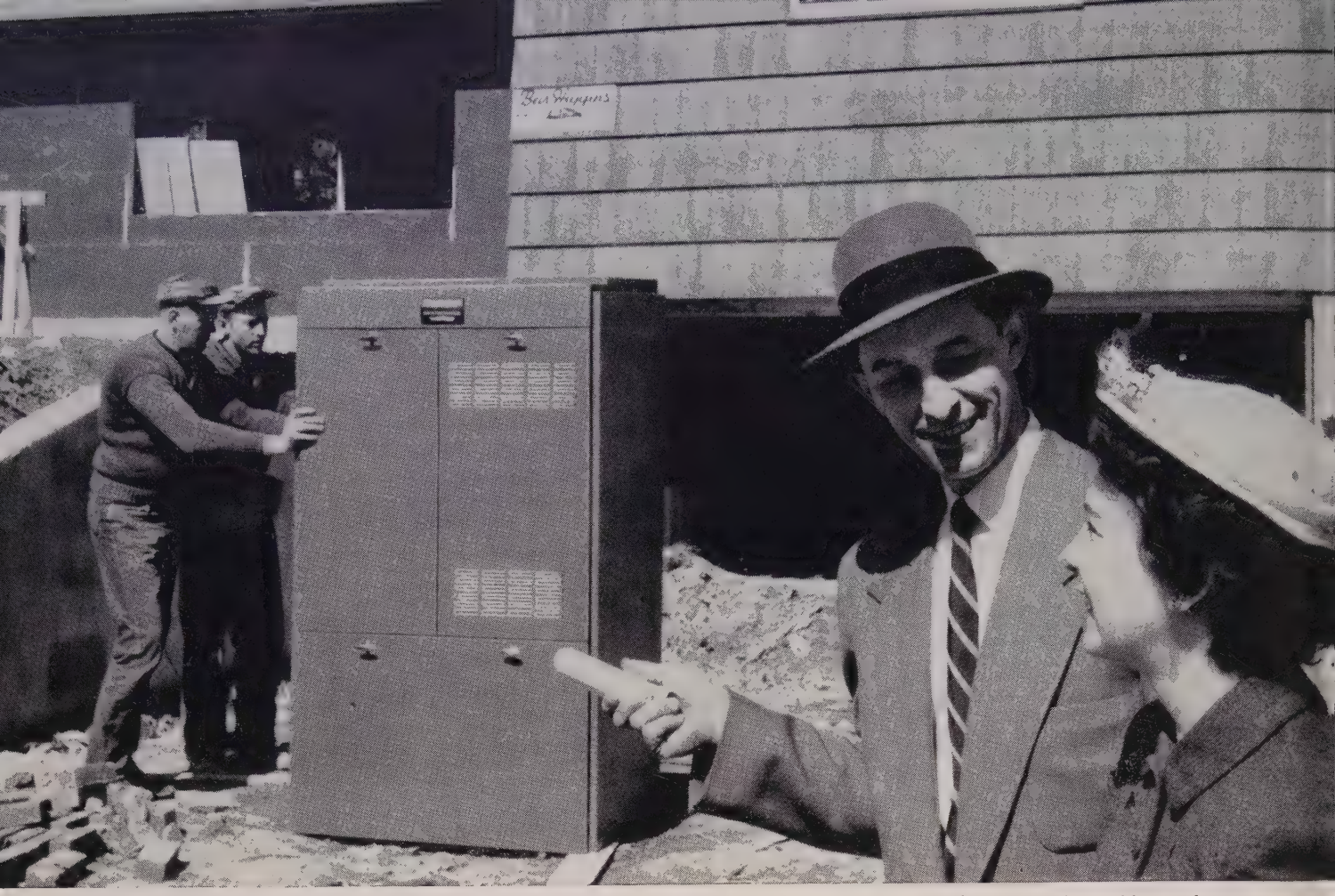
DIESEL ENGINES • TRACTORS • MOTOR GRADERS • EARTHMOVING EQUIPMENT



NEW PRODUCT in the air conditioning field is Worthington's ultra-modern winter and summer home air conditioner. It's a compact package that heats, cools, circulates, filters, and controls humidity. Like every Worthington product, this good-looking unit is designed and built for a lifetime of quiet, efficient service.

Making today's BIG news in air conditioning

NEW BUILDING in New York is the glass-sheathed Manufacturer's Trust Building. It's cooled by a Worthington central station system—so big it does the same job as melting 300 tons of ice daily.

NEW LIFE FOR OLD STORES. Shoppers stay longer, buy more in stores cooled by Worthington units with the new "Million Dollar" compressor. New 3-D circulation aims comfort right where you want it.

Worthington's new residential air conditioners, packaged units, big central station systems — all are making headlines in the air conditioning field. And the same research and engineering skills responsible for their development are applied to all Worthington products — engines, turbines, compressors, construction machinery, as well as pumps.

For the complete story of how you can fit into the Worthington picture, write F. F. Thompson, Mgr., Personnel & Training, Worthington Corporation, Harrison, New Jersey. **4.25D**

See the Worthington representative when he visits your campus

See the Worthington Corporation exhibit in New York City. A lively, informative display of product developments for industry, business and the home. Park Avenue and 40th Street.

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When you're thinking of a good job—think high—think Worthington

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More and better jobs for more people

GENERAL MOTORS President Harlow H. Curtice speaking:

"Just as an example of how job opportunities in General Motors have grown, here is what has happened since 1940.

"In 1940, we had 233 thousand employes on our payrolls in the United States and Canada. In 1955, our employment totals 520 thousand —an increase of 287 thousand good jobs in only 15 years."

It stands to reason that a climate where job opportunities expand with such rapidity must be especially fruitful of career opportunities for young men holding engineering degrees.

For, in the final analysis, the very life's blood of our organization is the never-ending production of "more and better things for more people"—and that, very definitely, requires the engineering mind at its best.

In point of fact, although engineering graduates comprise a mere two per cent of total GM employment, they will eventually fill about forty per cent of executive posts if the established pattern continues.

Why not, then, look into the possibility of enjoying a rewarding career as a GM engineer? You'll be interested in a big new 136-page handbook entitled, "Job Opportunities in General Motors." Your college library or placement office should have it.

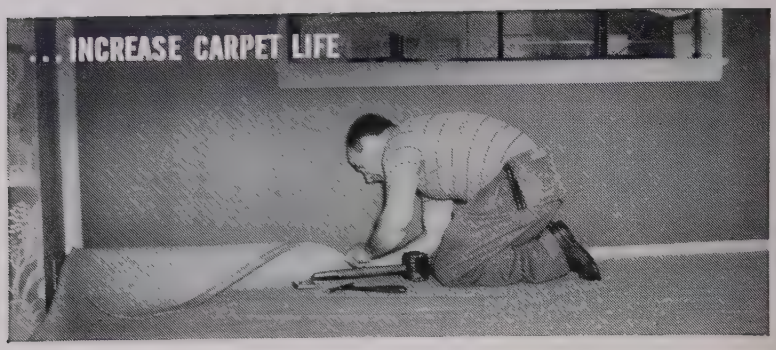
GM Positions Now Available In These Fields:

MECHANICAL ENGINEERING
ELECTRICAL ENGINEERING
CHEMICAL ENGINEERING
METALLURGICAL ENGINEERING
INDUSTRIAL ENGINEERING

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

HOW HERCULES HELPS...



THE BACK COUNTS, TOO, in the manufacture of carpets. Hercules Dresinol® solvent-free resin dispersions used in conjunction with latex, starch and pigments, provide durable backings for popular-priced carpets. Dresinol furnishes either flexibility or stiffness; adds body to the carpet and improves adhesion of the backing for all types of cotton, wool and mixed fiber carpets.

NEW ANTHRACITE-BURNING BOILERS, clean and compact, make playrooms of basements the year round; even remove ashes automatically. Mining the millions of tons of anthracite used annually for residential, commercial and industrial uses would be impossible without explosives. For more than forty years, Hercules has pioneered in blasting techniques and equipment to increase the efficient and safe use of explosives in mining, quarrying, construction, and farming.

AIMING FOR THE "POCKET", this bowler wants the alley he uses highly polished and free of "ruts". That's why bowling alley surfaces are protected with nitrocellulose lacquer to keep them in top condition. The fastest drying protective coating known, lacquer makes it possible to put an alley back in play within hours after it has been refinished. This same tough finish protects bowling pins and other sports equipment.

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Two years ago we announced the world's most powerful production aircraft engine.

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Today the J-57 is still unmatched anywhere — an important factor in this country's supremacy in the air.

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Division of United Aircraft Corporation

East Hartford 8, Connecticut

to the well too often

There are easier ways to get a drink.

And engineering graduates will be called upon to develop them. They'll have to help supply and distribute the billions of gallons of water needed daily by homes and industry. Water that will be increasingly hard to find.

But when they find it, they can rely on cast iron pipe to carry it. Practically every city in America — large or small — uses it for water and gas mains. In over 60 of them cast iron pipe has served for a century or more.

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CAST IRON

CAST IRON PIPE SERVES FOR CENTURIES

A Campus-to-Career Case History

"This is what I did yesterday"

"I like a job that keeps me jumping," says Bill Jermain, C.E. from Marquette, '52. "And my first management assignment with Wisconsin Telephone Company does just that. I'm Service Foreman at Sheboygan, with nine installers, and that means variety of responsibility. But judge for yourself. Here's a quick run-down of what I did yesterday, on a typical day—

8:10—"Checked day's work schedule. One of my new men was putting in a buried service wire, and I went over the job specs with him to be sure he had things straight.

8:30—"Answered mail while my clerk checked time sheets from previous day.

9:30—"Out to supervise installation of the first aluminum Outdoor Telephone Booth in my exchange. Reviewed the assembly instructions with the installers, then arranged for special tools and bolts to be delivered to the job.

11:30—"Drove across town. Made a 'quality inspection' on a telephone installed last week. Everything checked O.K.

12:00—"Lunch.

1:00—"Picked up film for next day's safety meeting. Watched the film, made notes for discussion.

2:00—"Met with moving company manager to estimate cost of telephone cable lifting for a house moving job. Drove the route he had planned and worked out schedule for construction crews.

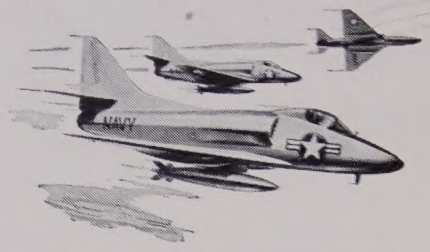
3:30—"Returned to aluminum booth installation. Went over wiring specs with the electrician.

4:00—"Stopped at Central Office to pick up next day's orders. Met installers at garage as they checked in and assigned next day's work."

Bill has been in his present job about a year, and is looking forward to new responsibilities as his experience increases . . . as are the many young college men who have chosen telephone careers. If you'd be interested in a similar opportunity with a Bell Telephone Company . . . or with Bell Telephone Laboratories, Western Electric or Sandia Corporation . . . see your Placement Officer for full details.

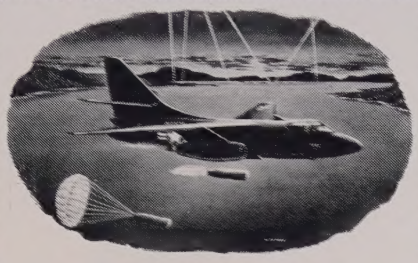
BELL TELEPHONE SYSTEM

F4D, "SKYRAY"— only carrier plane to hold official world's speed record



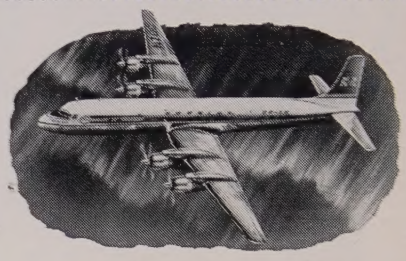
A4D, "SKYHAWK"— smallest, lightest atom-bomb carrier

RB-66 — speedy, versatile jet bomber



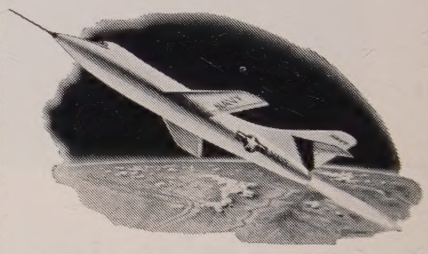
A3D, "SKYWARRIOR"— largest carrier-based bomber

C-124, "GLOBEMASTER"— world's largest production transport



DC-7 "SEVEN SEAS"— America's finest, fastest airliner

"NIKE"— supersonic missile selected to protect our cities



D558-2, "SKYROCKET"— first airplane to fly twice the speed of sound

Engineers: join this winning team!

At DOUGLAS you'll be joining a company in which the three top executive officers are engineers...you'll be associated with men who have designed the key airplanes and missiles on the American scene today! Nothing increases an engineer's ability faster than working with other engineers of top calibre.

Not only is Douglas the largest manufacturer of commercial aircraft in the world, but it also produces outstanding aircraft and missiles for *every* branch of the armed services! This diversity, besides giving you job security, provides unequalled opportunity for the engineer with an eye to the future.

Challenging opportunities now exist in the following fields:

Mechanical design
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Power plant installation design
Weapons delivery
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Thermodynamics
Electronic computers
Systems analysis
Aircraft air conditioning
Hydraulics
Stress analysis
Servo mechanisms
Acoustics
Electronics
Mechanical test
Structural test
Flight test
Process engineering
Missiles

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DOUGLAS AIRCRAFT COMPANY, INC.

C. C. LaVene, Employment Manager...Engineering General Office
3000 Ocean Park Blvd....Santa Monica, California

PHOTOGRAPHY AT WORK—No. 15 in a Kodak series

How good is this spot for a poster?

—photography was put on watch to find out

Photography adds striking realism to highway poster.

In the hands of Alfred Politz Research, Inc., camera and film sampled the traffic, spaced test periods, stayed on the job, never got tired and reported with complete accuracy.

You can gauge a magazine's readers by its circulation—or a newspaper's by its daily sales. But how can you measure the potential audience of an outdoor poster?

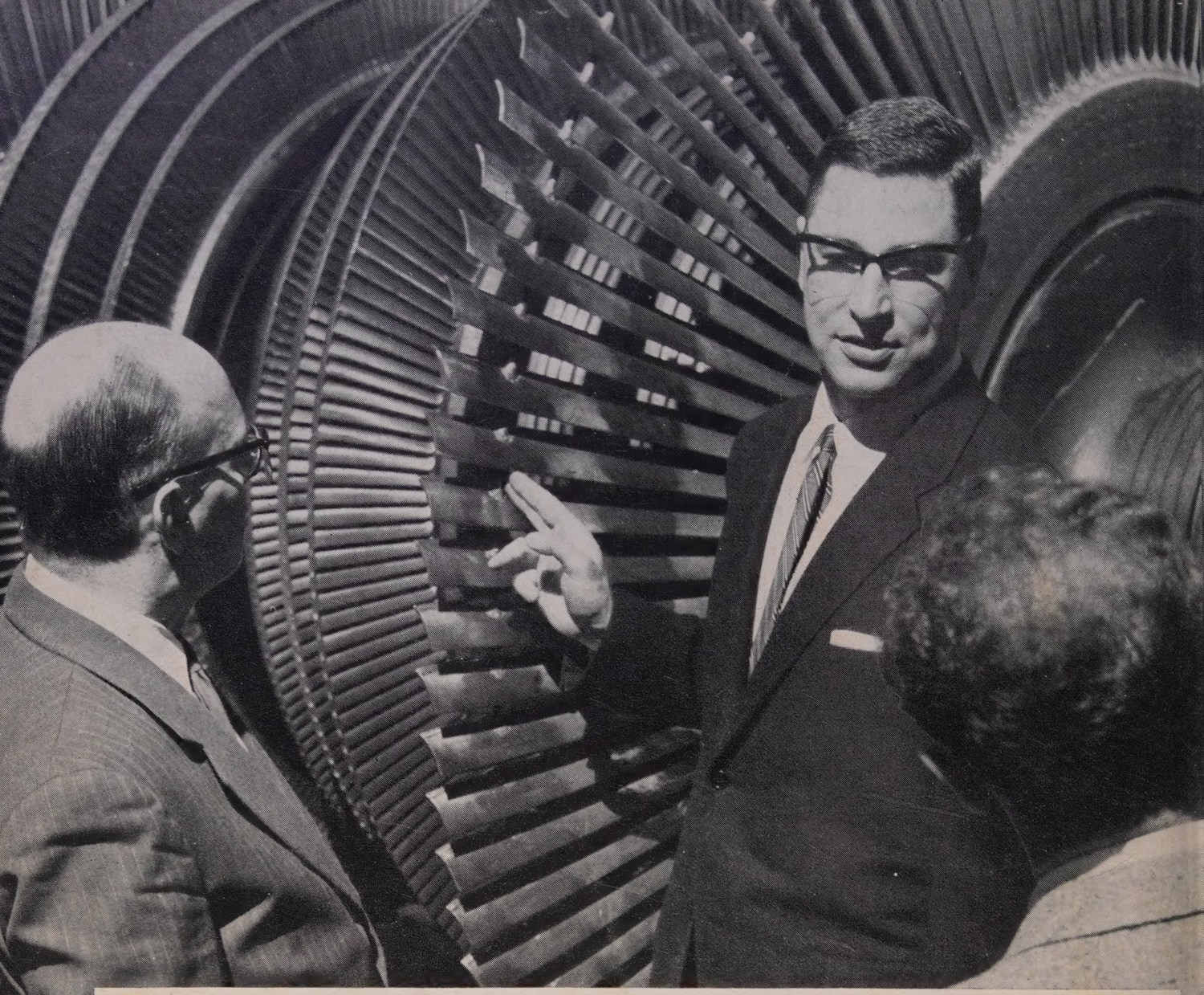
Alfred Politz Research, Inc. worked out an answer. Figuring that anyone the poster can "see" can see the poster, they set up an automatic camera which recorded periods of passing traffic at regular intervals. Counting the people and cars on the film records gave accurate figures on the viewers of the poster and made it possible to compute its gross man-hours of exposure.

Counting people comes as easily for photography as counting phone calls, metal rods or tons of coal. It is one of the many ways it is serving all kinds of business and industry. In small businesses and large it is helping to save time, cut costs, reduce error, design new products and improve production.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning serviceman, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Kodak
TRADE-MARK

Eastman Kodak Company, Rochester 4, N. Y.



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As a G-E representative in one of the Company's 152 Apparatus Sales Offices in key cities, you work with customers to determine what design, new development or system will best serve their needs. The program offers—in addition to exciting district work—career opportunities in the Company's headquarters marketing and sales operations. SJ-526

*ILLUSTRATION: *Sales Engineer and customers discuss turbine rotor construction. Glasses are factory safety measure.*

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